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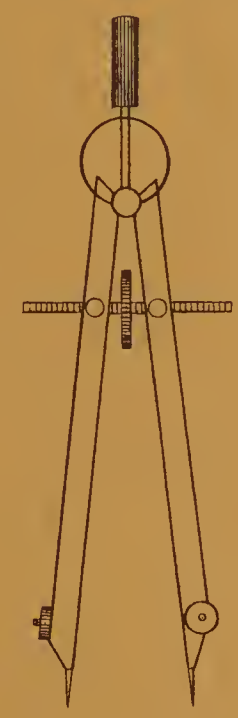
CARTOGRAPHIC NOTEBOOK

A Brief Guide to some aspects of Cartographic Design

Stephen Meszaros



U.S. Department of the Interior
Bureau of Land Management
Arizona State Office

Phoenix, Arizona

2001

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2001

THE GOLDEN RULE OF CARTOGRAPHY:

"A Map must be Readable, Understandable, and Accurate"

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2001

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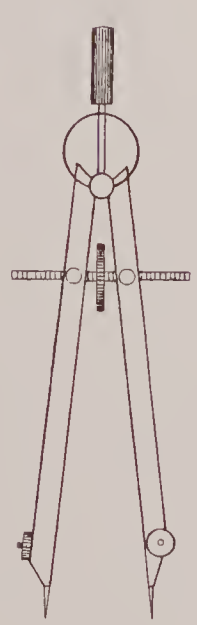

Phoenix, Arizona

2001

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ABSTRACT

This document describes some basic elements of cartography for the novice map maker. It does this by means of narrative text and a variety of sample maps which indicate common cartographic problems and their solutions. Information on graphics and presentations is also included.

AUTHOR'S NOTE

I would like to thank my colleagues at the Bureau of Land Management in Arizona for the great variety of maps made available to me over the past decade – only a few of which are used here. All of the maps discussed in this publication were actually published, presented in lectures, or used in displays and exhibits.

I would also like to acknowledge Mr. Larry Taddia, former chief of the cartography unit at the BLM Arizona State Office (and now retired). Larry was one of the true professionals in cartography, combining expert draftsmanship and extensive knowledge of the field with common sense leadership. If his expertise had been followed, a much better quality of map would have been produced than is apparent in this document.

TABLE OF CONTENTS

INTRODUCTION

The personal computer (PC) revolution of the past decade has made it possible for the average worker, using various graphics programs, to produce maps for publication, presentation, display, and other purposes. Unfortunately, many of the people making these products do not have a professional cartographic background – in either education or experience. The result has been the creation of a large number of poor quality maps. Consequently, this *Cartographic Notebook* (hereafter referred to as the *Carto Notebook* or just *Notebook*) has been written to assist those "new map makers" who have the computer expertise to draft the maps but lack the design knowledge of what elements a map requires to be successful.

What this *Notebook* **is not**: This *Notebook* is not meant to be an exhaustive tome on all aspects of cartography. There are many excellent textbooks available that cover the subject in detail (see the Bibliography for several examples).

What this *Notebook* **is**: This *Notebook* is intended to be a very general, brief, practical guide to a few of the most basic elements of map design. It includes examples of poor-quality maps, explains why they are unacceptable, and indicates how they should be corrected.* In particular, the "common sense" of map design is stressed. Material on the presentation of graphic visuals is also available, in the Appendix.

* All the maps and graphics in this *Notebook* are real examples. They were actually used in publications, presentations, or displays by the BLM.

THE ORGANIZATION OF THE *CARTO NOTEBOOK*

The *Notebook* starts with "The Golden Rule of Cartography" which summarizes the three basic factors that all maps must have to be successful. "Maps: Part I" contains the various sample maps that the reader is to critique. "Map Elements" describes the major parts of a map. "Maps: Part II" edits and explains the problem areas of the maps shown in Part I. "Cartographic Essays" discusses the more philosophical or "big picture" aspects of cartographic design and production. Finally, the "Appendices" contain information on graphic visuals, presentation techniques, and type size rules.

USING THE *CARTO NOTEBOOK*

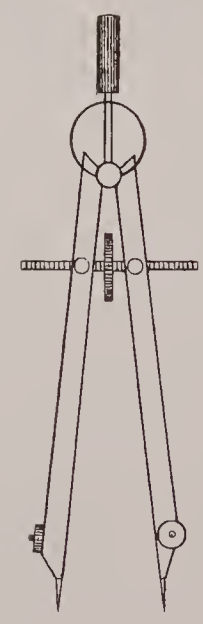
The *Notebook* has been designed to be an "active tool" to aid you, the reader, in your understanding of how to create a successful map. In order to accomplish this, you are asked to review the "problem" maps in Part I. Each has a facing lined "Notes" page for written comments. This is your chance to test your own knowledge of map design. You are encouraged to critically examine each map and indicate, on the facing page, what is wrong with it (if anything – I have included a couple that are OK). This exercise will introduce you to "thinking cartographically." After completing Part I, go on to Part II. Part II displays the same maps as in Part I except this time the author's comments about the maps are on the facing pages. Did you notice the same map problems as the author? Did you see any that he missed?! Reading the Map Elements and Cartographic Essays sections, as well as the Appendices, will round out the information in this *Notebook.*

THE GOLDEN RULE OF CARTOGRAPHY:

"A Map must be Readable, Understandable, and Accurate"

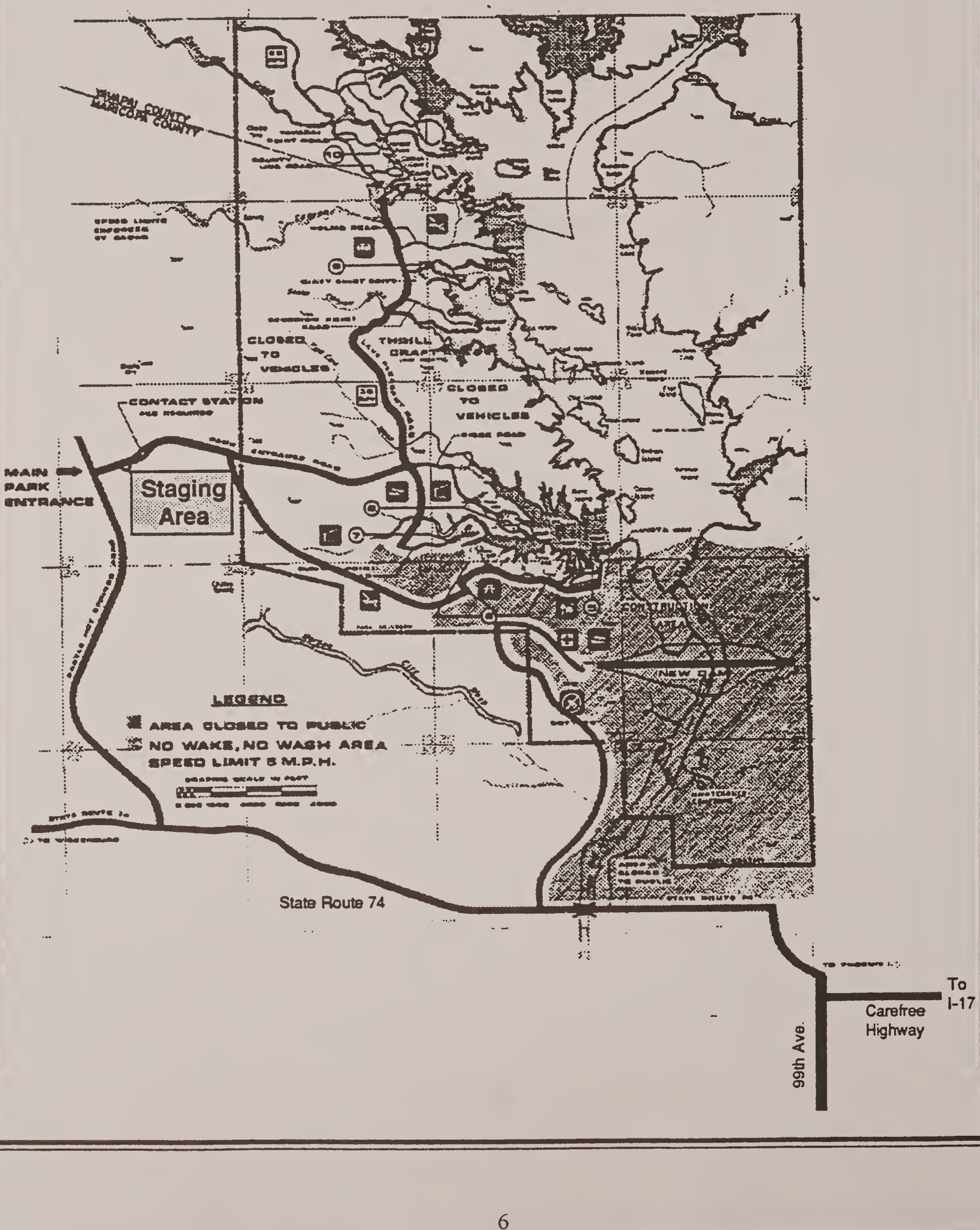
In order for a map to be successful it should have the three virtues of being readable, understandable, and accurate. First, it must be readable. The text should be large enough to see, the line weights bold enough to be visible, and the design not so complex or cluttered that it is, in fact, unreadable. Second, the map must be understandable. Can a map be readable, but not understandable? Of course! If I give you a map with fully readable text – but it is in *Mandarin Chinese* – I doubt that you will be able to comprehend it (unless, perchance, you happen to read Mandarin Chinese!) The point is that the subject matter of the text, the educational level of the presentation, and the adequate explanation in the legend must be appropriate to the audience. Otherwise they will not understand it. Finally, a map must be accurate. This is really common sense! If a map is readable and understandable, but the data presented upon it is incorrect, then the map is worthless. Correct information is basic to any and all maps.

These three factors: readability, understandability, and accuracy, may be said to form the basis of the "Golden Rule of Cartography." Any map that does not contain these elements will be a failure. A map that has these elements incorporated into its design is well on the way to being a success.

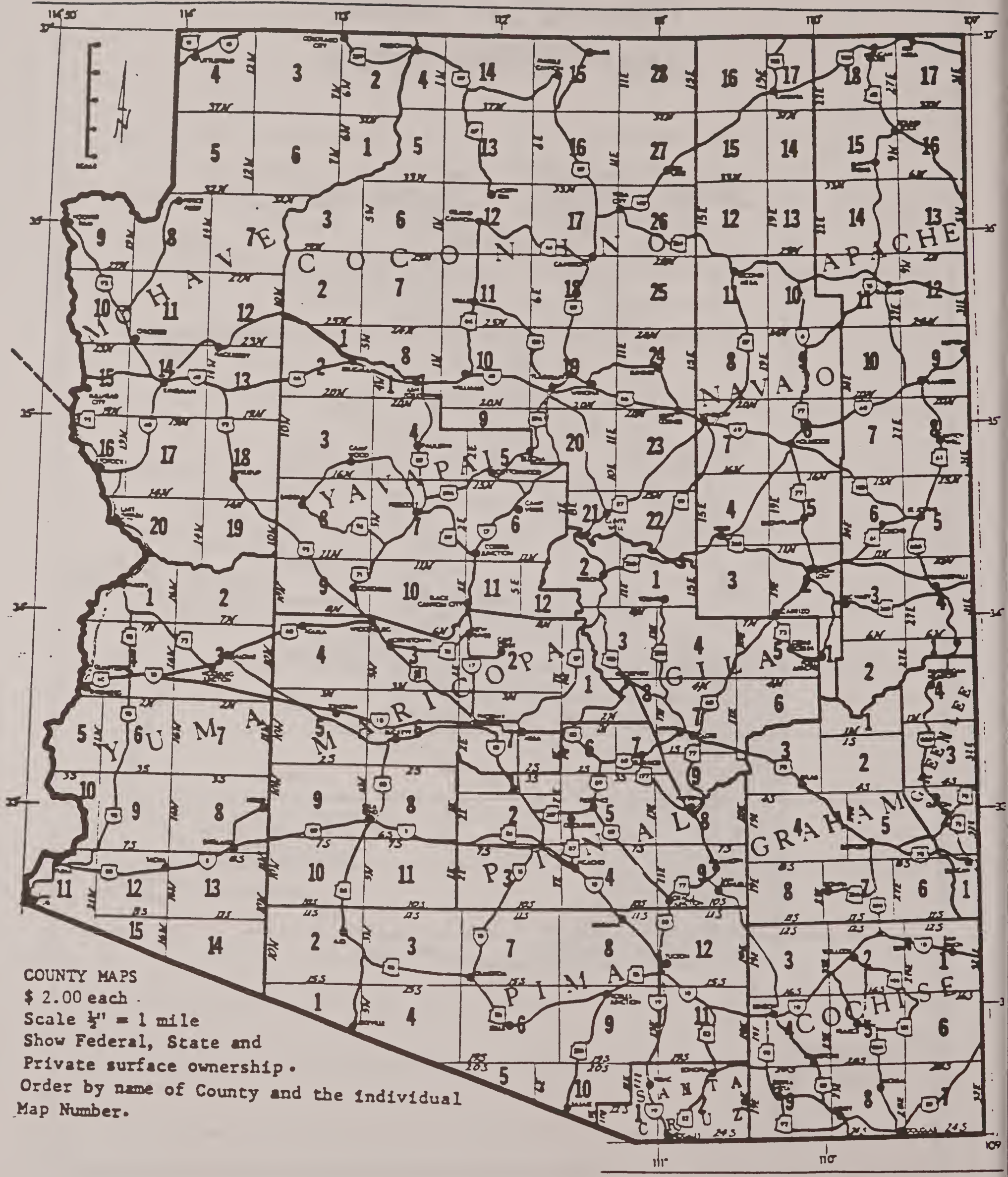


MAPS: PART I

LAKE PLEASANT ADOPT-A-SHORE



NOTES



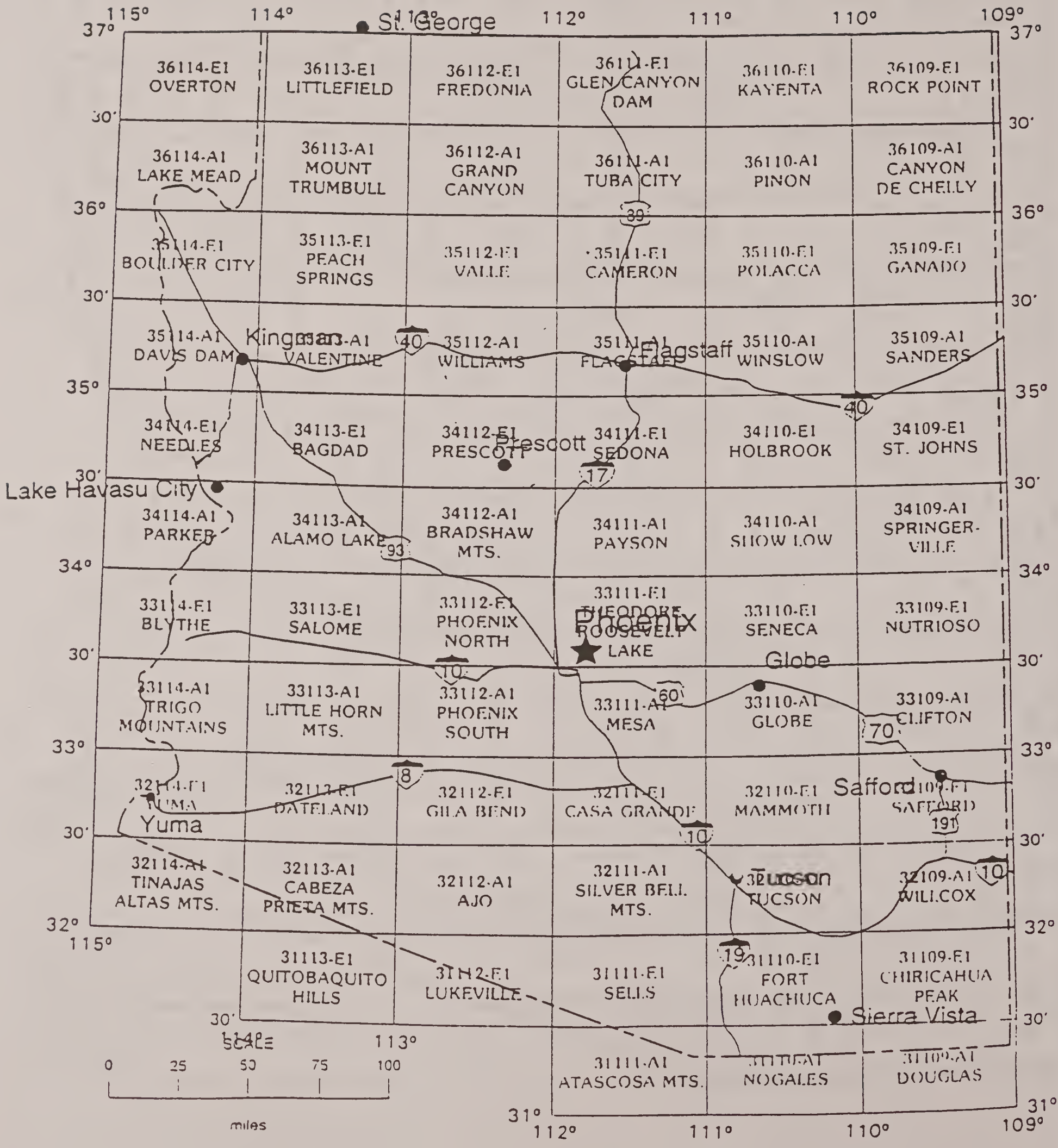
COUNTY MAPS
$ 2.00 each
Scale ½" = 1 mile
Show Federal, State and
Private surface ownership.
Order by name of County and the individual
Map Number.

NOTES

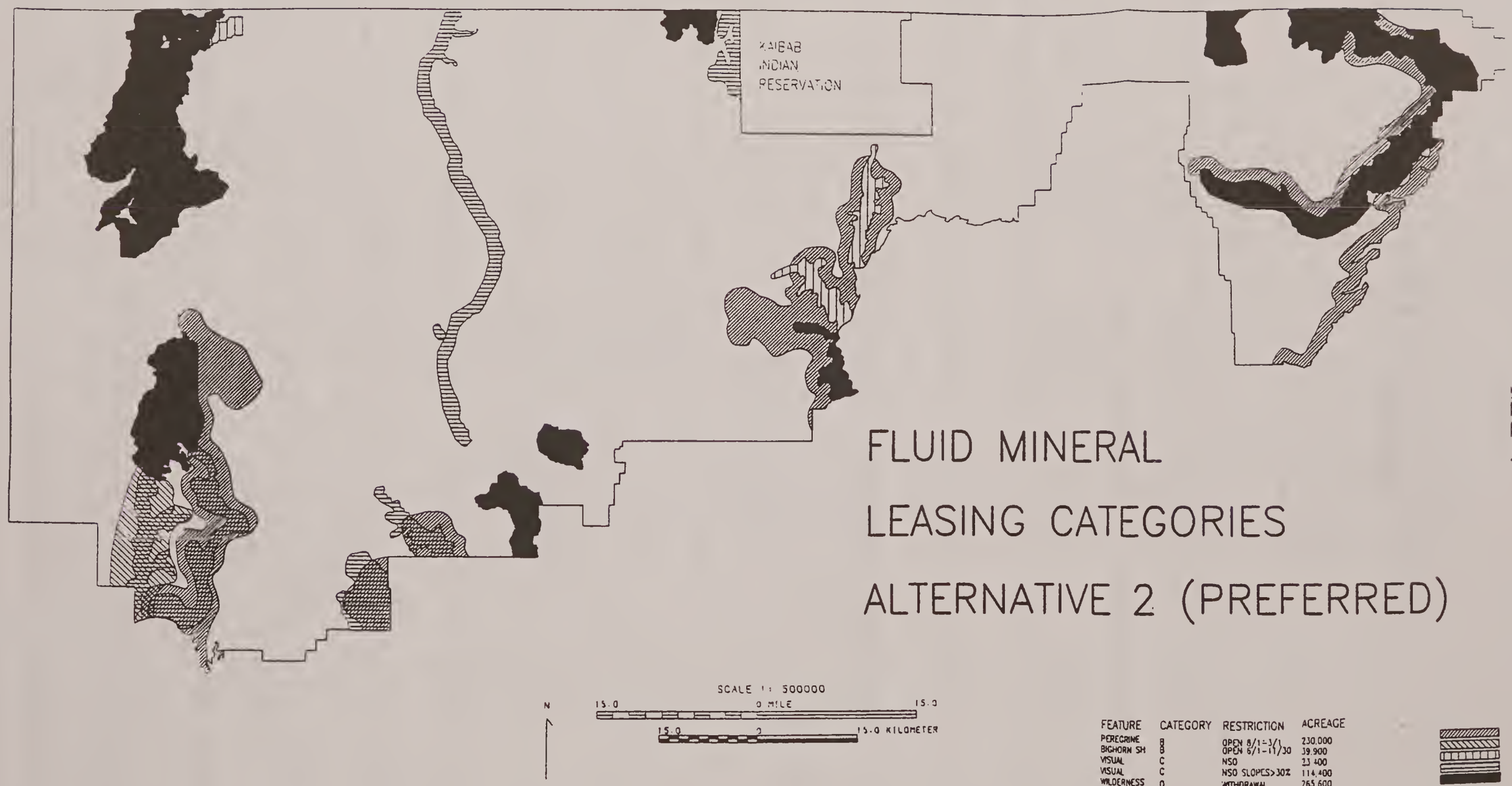
MAP 3

ARIZONA

1:100 000 SCALE



NOTES



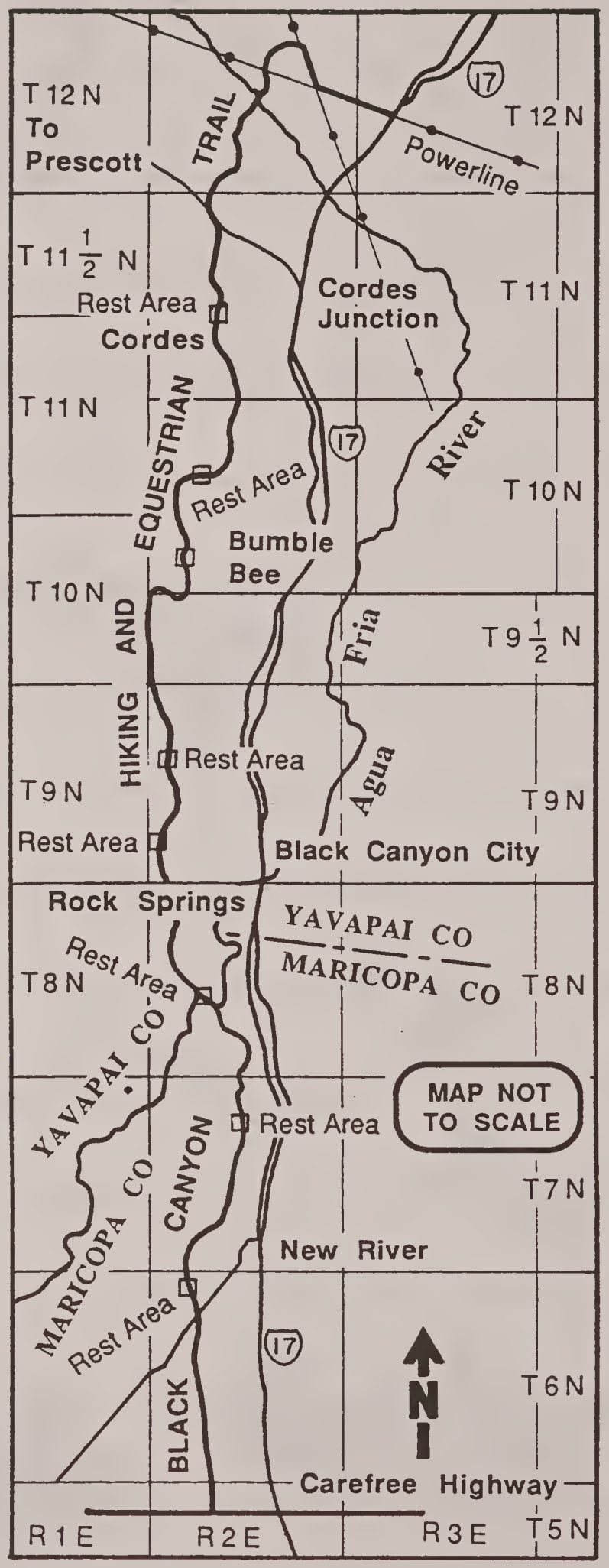
FLUID MINERAL LEASING CATEGORIES ALTERNATIVE 2 (PREFERRED)

FEATURE	CATEGORY	RESTRICTION	ACREAGE
PEREGRINE	B	OPEN 8/1-3/1 OPEN 6/1-11/30	230,000
BIGHORN SH	B		39,900
VISUAL	C	NSO	23,400
VISUAL	C	NSO SLOPES>30%	114,400
WILDERNESS	D	WITHDRAWAL	265,600

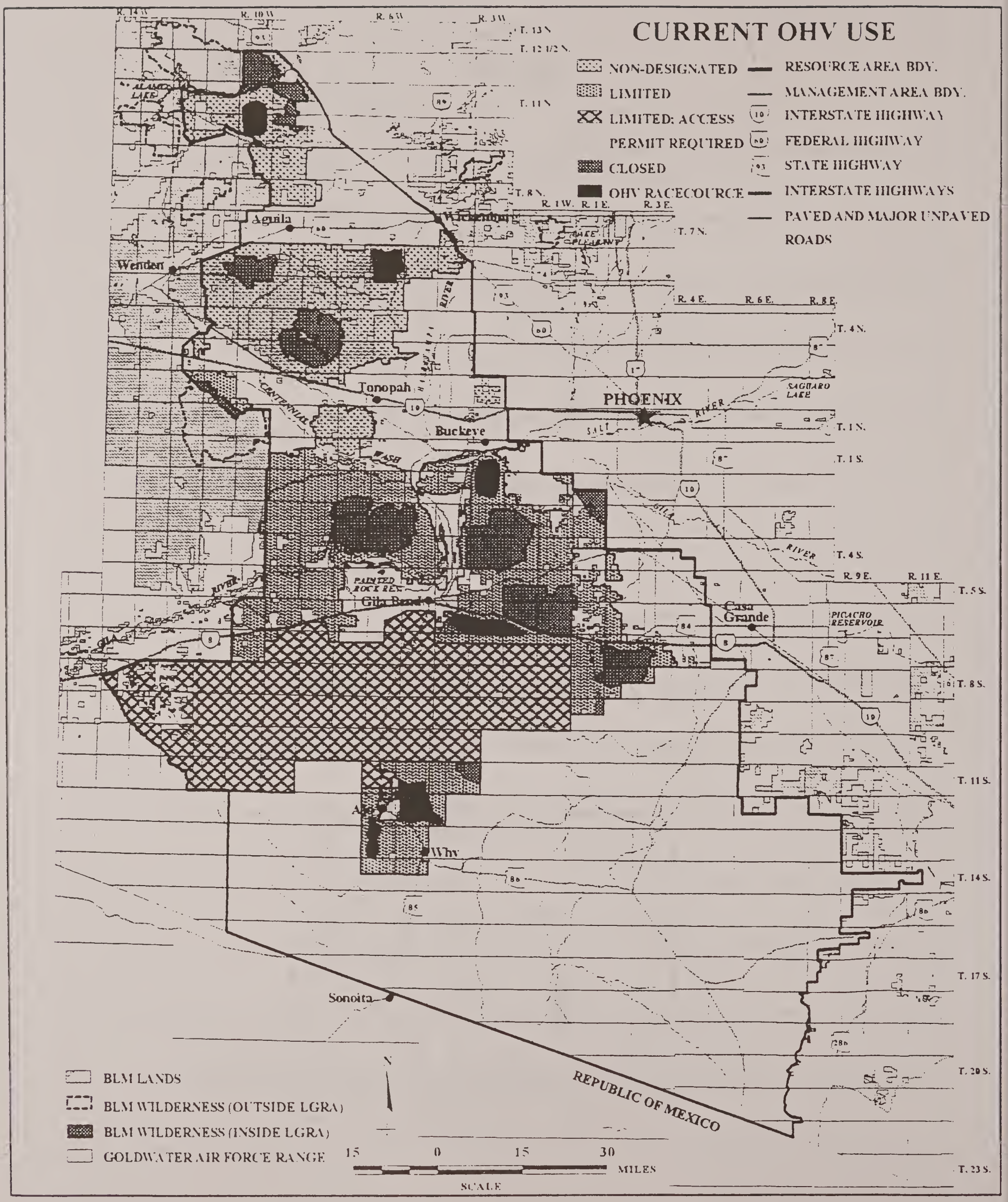
MAP 4

NOTES

MAP 5

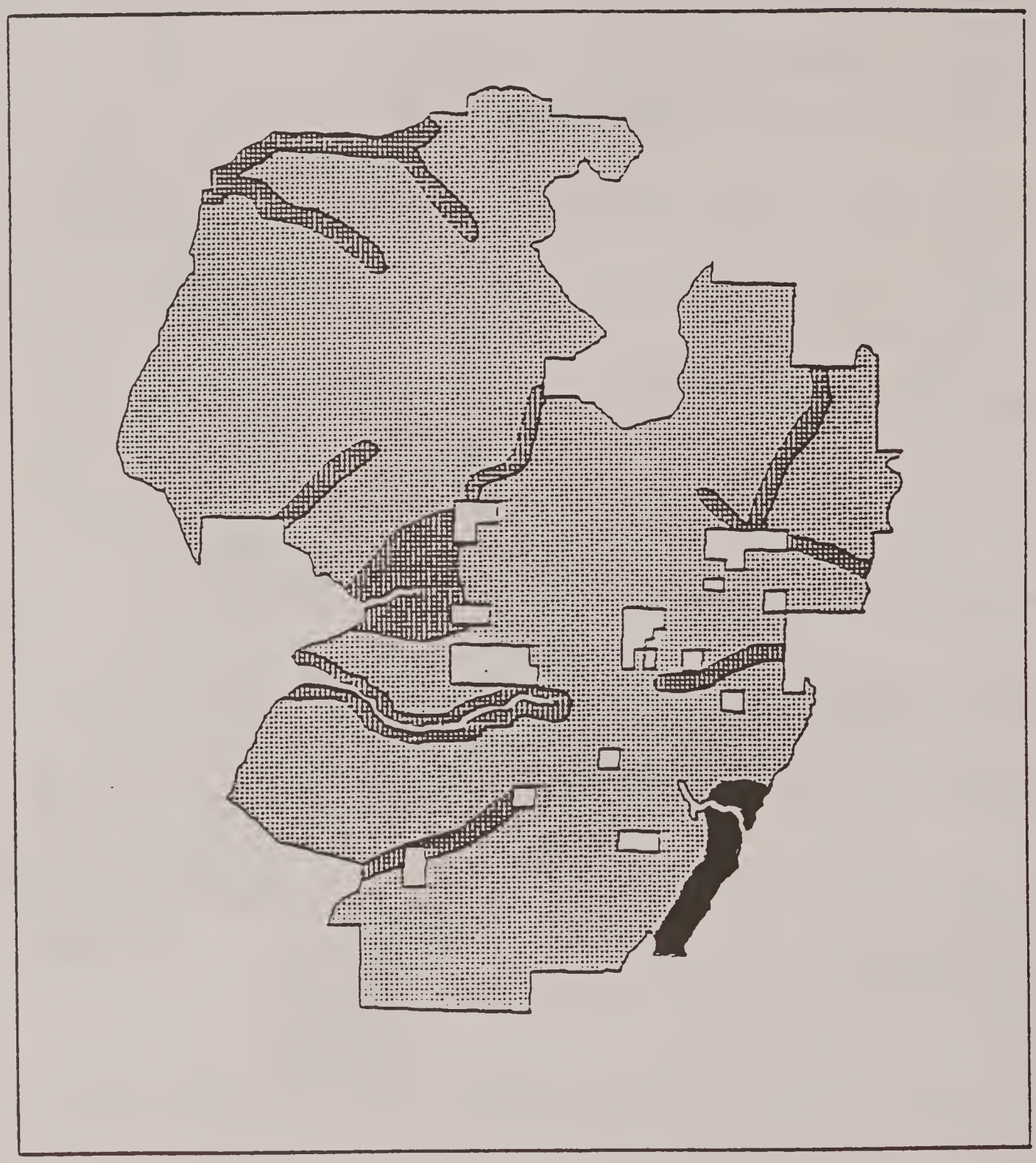

T 12 N
To
Prescott
TRAIL
17
T 12 N
Powerline
T 11 1/2 N
Rest Area
Cordes
Cordes
Junction
T 11 N
T 11 N
EQUESTRIAN
17
River
Rest Area
T 10 N
Bumble
Bee
T 10 N
AND
Fria
T 9 1/2 N
HIKING
Rest Area
Agua
T 9 N
T 9 N
Rest Area
Black Canyon City
Rock Springs
YAVAPAI CO
MARICOPA CO
Rest Area
T 8 N
T 8 N
YAVAPAI CO
MAP NOT
TO SCALE
Rest Area
CANYON
T 7 N
MARICOPA CO
New River
Rest Area
17
N
T 6 N
BLACK
Carefree Highway
R 1 E
R 2 E
R 3 E
T 5 N

NOTES


CURRENT OHV USE
NON-DESIGNATED
LIMITED
LIMITED: ACCESS PERMIT REQUIRED
CLOSED
OHV RACECOURCE
RESOURCE AREA BDY.
MANAGEMENT AREA BDY.
INTERSTATE HIGHWAY
FEDERAL HIGHWAY
STATE HIGHWAY
INTERSTATE HIGHWAYS
PAVED AND MAJOR UNPAVED ROADS
BLM LANDS
BLM WILDERNESS (OUTSIDE LGRA)
BLM WILDERNESS (INSIDE LGRA)
GOLDWATER AIR FORCE RANGE
15 0 15 30
MILES
SCALE
N
Aguila
Wenden
Tonopah
Buckeye
PHOENIX
Gila Bend
Casa Grande
Why
Sonoita
REPUBLIC OF MEXICO
ALAMO LAKE
PAINTED ROCK RES.
PICACHO RESERVOIR
SAGUARO LAKE
CENTENNIAL WASH
SALT RIVER
GILA RIVER
T. 13 N.
T. 12 1/2 N.
T. 11 N.
T. 8 N.
T. 7 N.
T. 4 N.
T. 1 N.
T. 1 S.
T. 4 S.
T. 5 S.
T. 8 S.
T. 11 S.
T. 14 S.
T. 17 S.
T. 20 S.
T. 23 S.
R. 14 W.
R. 10 W.
R. 6 W.
R. 3 W.
R. 1 W.
R. 1 E.
R. 3 E.
R. 4 E.
R. 6 E.
R. 8 E.
R. 9 E.
R. 11 E.

NOTES

Map 5
Wabayuma Peak Management Zones



UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

N

0 1 2
Miles

LEGEND

- Class I
- Class II
- Class III
- Private Inholdings

NOTES

- **Table Top Trail** - Located 25 miles west of Casa Grande • 2,100 to 4,356 foot elevation • 4.5 miles one way • for hiking and equestrian use • best during late fall, winter and early spring • moderate trail. For more information call (602) 580-5500.

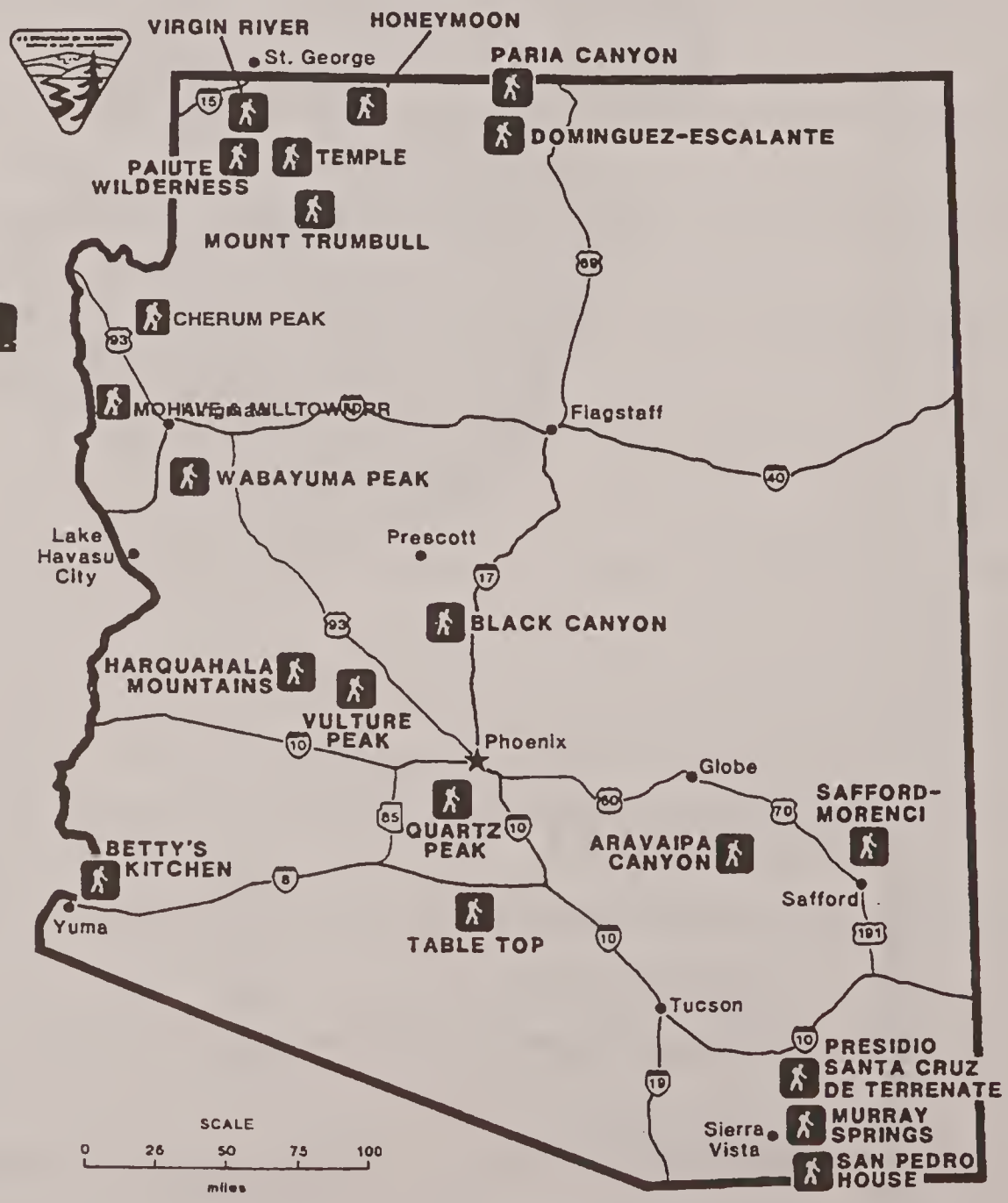
- **Temple Trail** - Located 55 miles southwest of Fredonia • 2,800 to 6,500 foot elevation • 80 miles one way • mostly vehicular access • year-round use • easy on established roadways, difficult in non-vehicular areas. For more information call (435) 688-3200.

- **Virgin River Interpretive Trail** - Located 16 miles northeast of Littlefield • 2,240 to 2,280 foot elevation • .25 miles one way • for interpretive use only • best during spring, fall and winter • easy trail. For more information call (435) 688-3200.

- **Vulture Peak Trail** - Located eight miles south of Wickenburg • 2,400 to 3,660 foot elevation • three miles total • hiking to summit, equestrian on surrounding foothills • best during fall, winter and spring • difficult on upper stretches, moderate on lower stretches. For more information call (602) 580-5500.

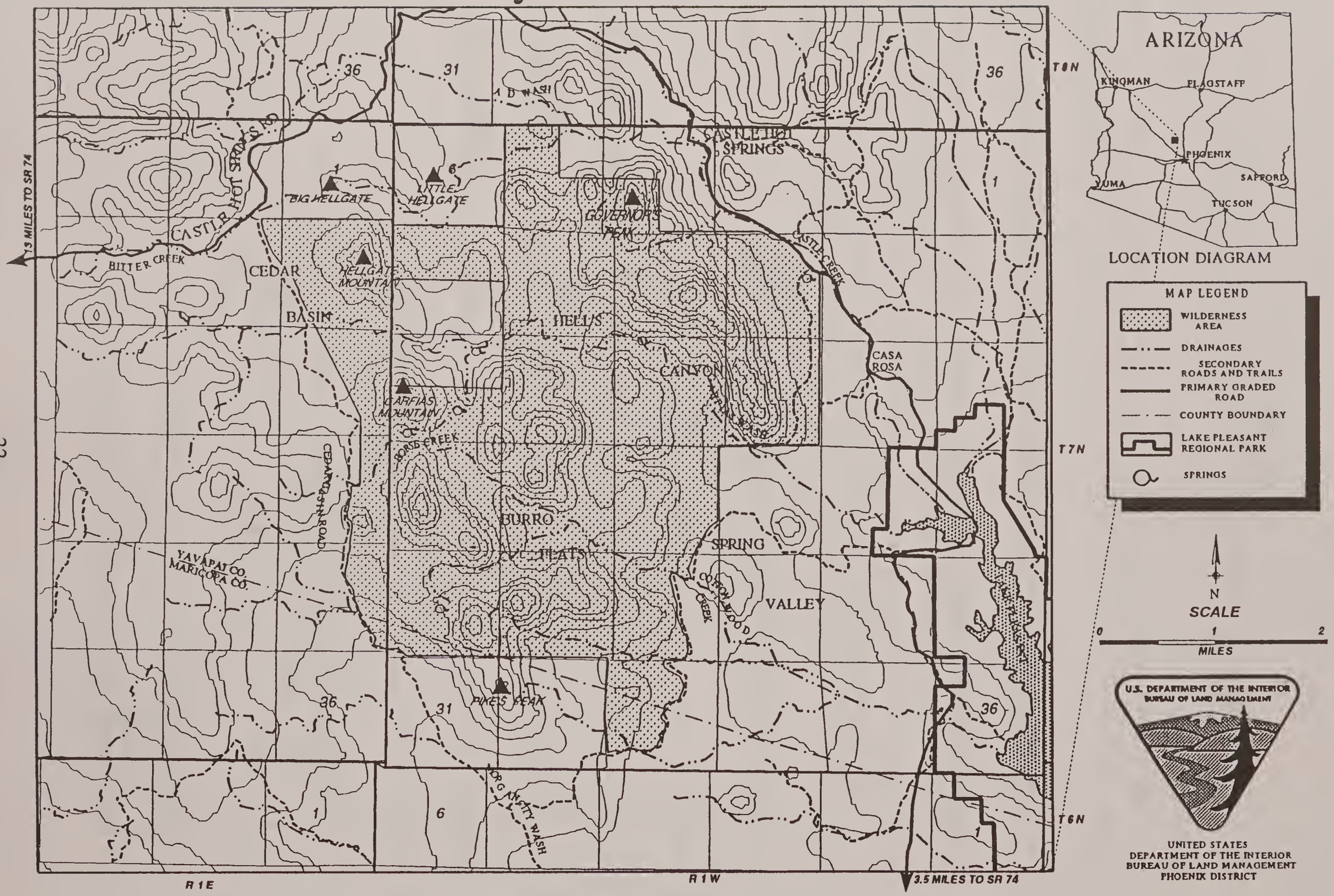
- **Wabayuma Peak Trail** - Located 30 miles southeast of Kingman • 6,047 to 7,601 foot elevation • three miles one way • for hiking only • best during late spring through fall • moderate trail, some cross-country. For more information call (520) 757-3161.

Arizona BLM Trails



NOTES

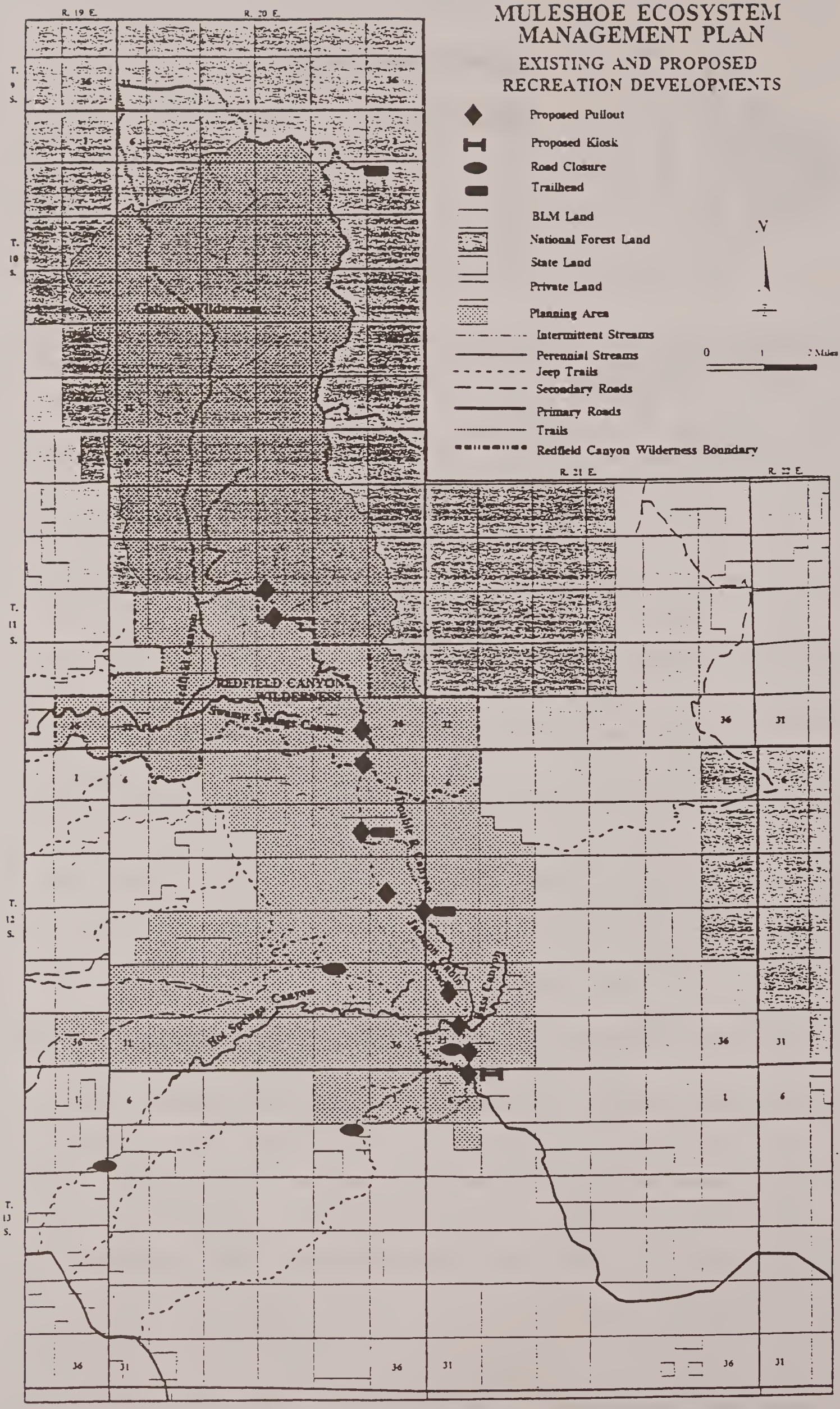
Hell's Canyon Wilderness



Map 1: General Area

NOTES

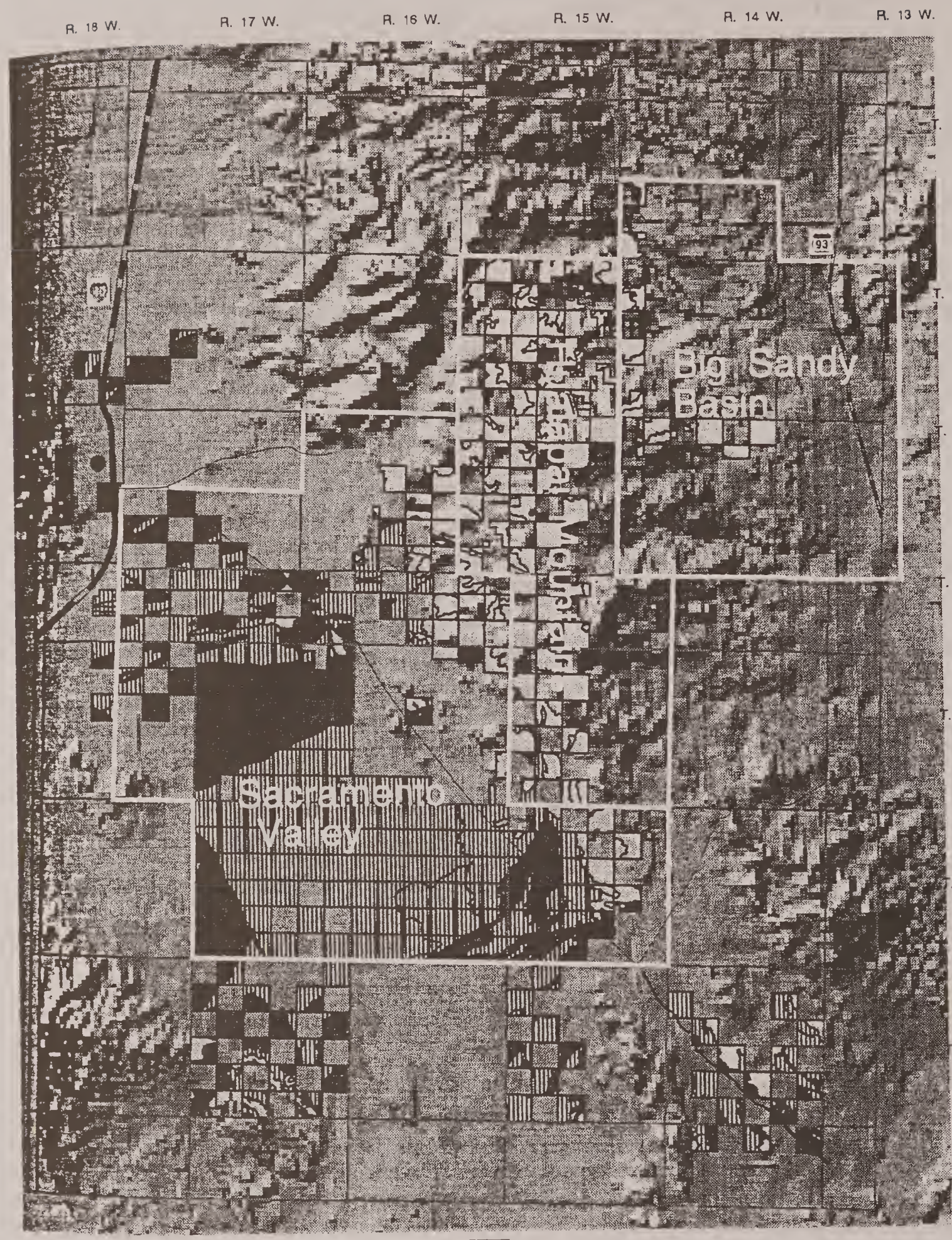
MAP 10


MULESHOE ECOSYSTEM MANAGEMENT PLAN
EXISTING AND PROPOSED RECREATION DEVELOPMENTS
Proposed Pullout
Proposed Kiosk
Road Closure
Trailhead
BLM Land
National Forest Land
State Land
Private Land
Planning Area
Intermittent Streams
Perennial Streams
Jeep Trails
Secondary Roads
Primary Roads
Trails
Redfield Canyon Wilderness Boundary
N
0
1
2 Miles
R. 19 E.
R. 20 E.
R. 21 E.
T. 9 S.
T. 10 S.
T. 11 S.
T. 12 S.
T. 13 S.
Galiuro Wilderness
REDFIELD CANYON WILDERNESS
Swamp Springs Canyon
Double R Canyon
Jackson Cabin
Hot Springs Canyon
36
31
1
6

NOTES

MAP 11

Map 5. Hualapai Mountain/Dutch Flat Area
Hydrologic Study Area and Erosion Potentials

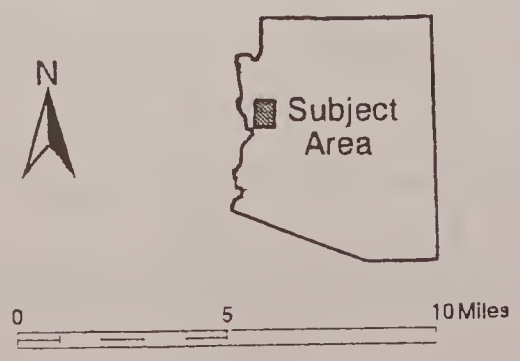


LEGEND

- Severe Erosion Potential
- Moderate Erosion Potential
- Slight Erosion Potential
- Boundaries of Hydrologic Study Area
- Major Road
- Secondary Road

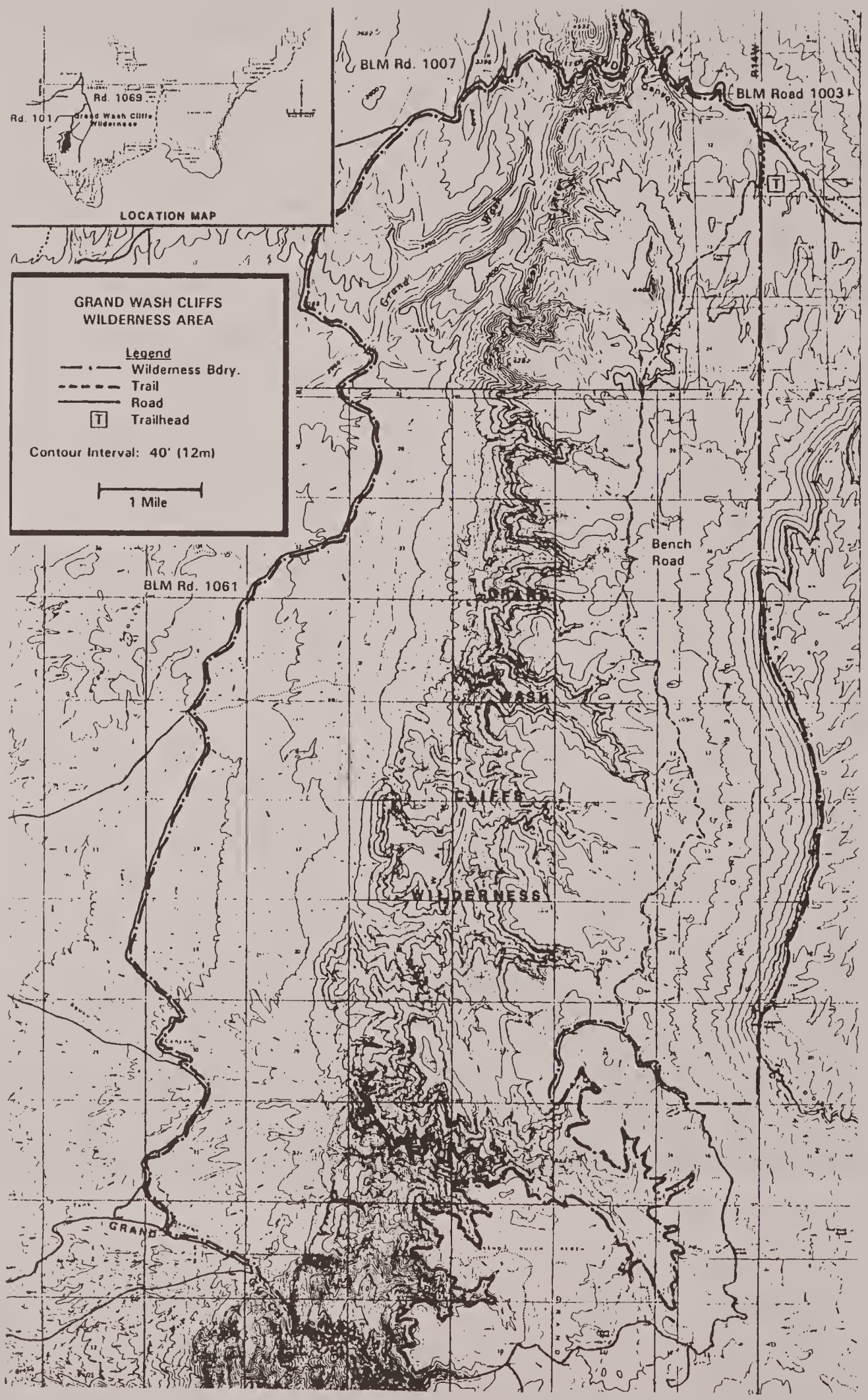
Topography is from 1:250,000 digital elevation model

Hualapai Mountain Exchange



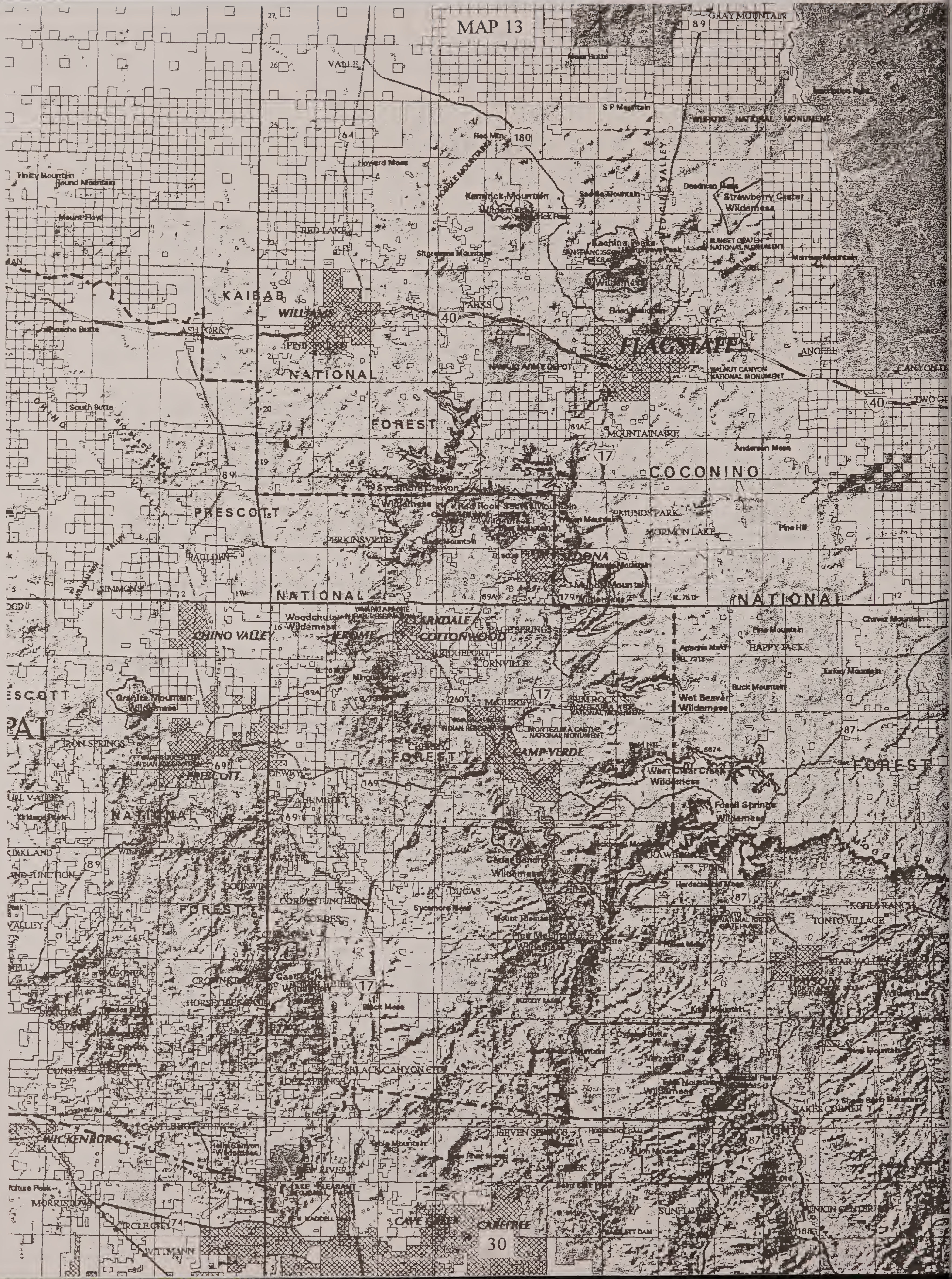
NOTES

MAP 12


LOCATION MAP
Rd. 1069
Rd. 101
Grand Wash Cliffs Wilderness
GRAND WASH CLIFFS
WILDERNESS AREA
Legend
Wilderness Bdry.
Trail
Road
Trailhead
Contour Interval: 40' (12m)
1 Mile
BLM Rd. 1007
BLM Road 1003
R14W
Bench
Road
BLM Rd. 1061
GRAND
WASH
CLIFFS
WILDERNESS
GRAND

NOTES

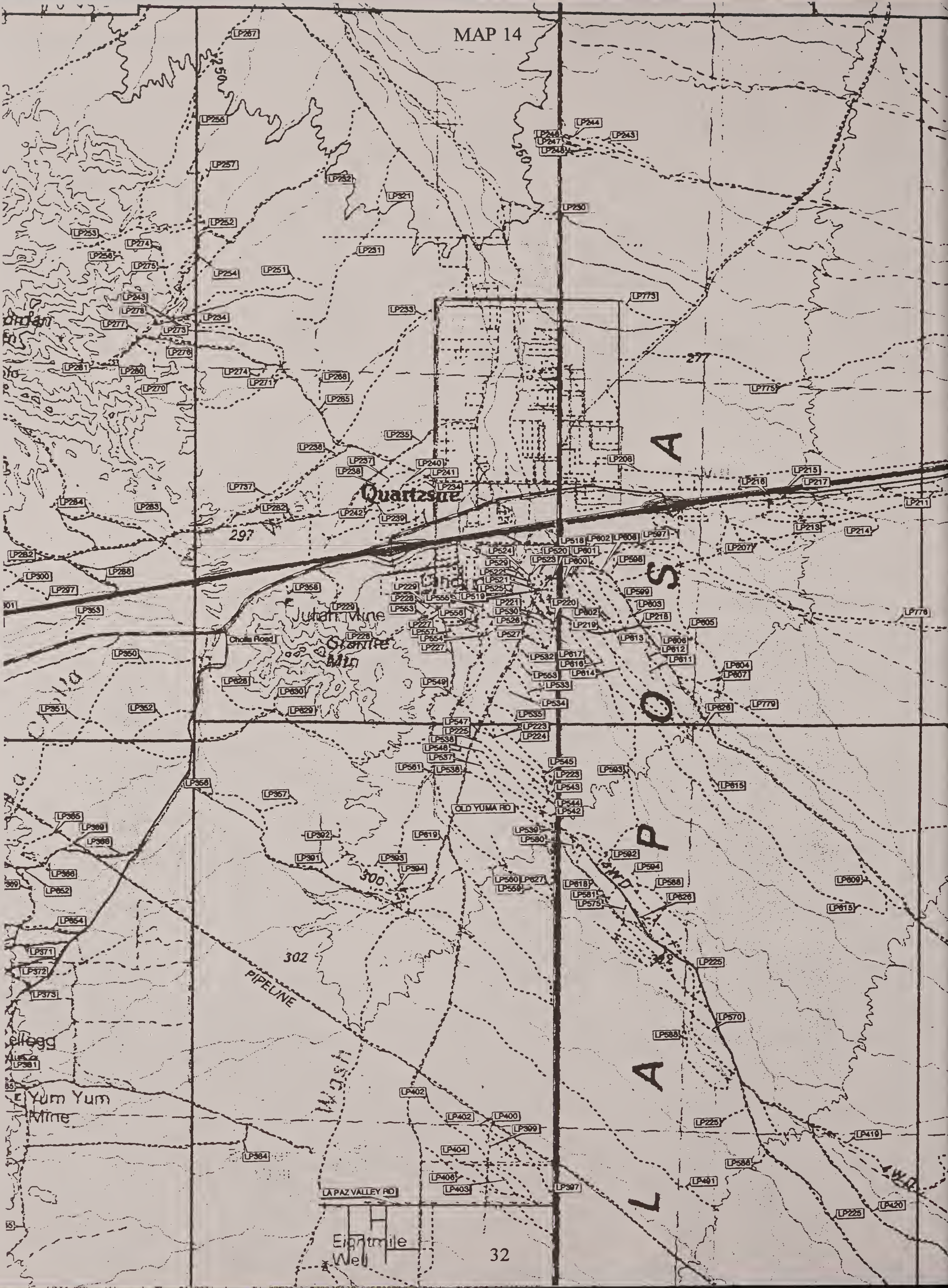
MAP 13



GRAY MOUNTAIN
VALLE
S P Mountain
WUPATKI NATIONAL MONUMENT
Red Mtn.
Howard Mesa
HOBBLE MOUNTAINS
Kendrick Mountain Wilderness
Strawberry Crater Wilderness
SUNSET CRATER NATIONAL MONUMENT
RED LAKE
Kachina Peaks Wilderness
KAIBAB
WILLIAMS
ASH FORK
PARKS
FLAGSTAFF
ANGELL
NATIONAL
NAVAJO ARMY DEPOT
WALNUT CANYON NATIONAL MONUMENT
South Butte
FOREST
MOUNTAINAIRE
Anderson Mesa
COCONINO
PRESCOTT
Sycamore Canyon Wilderness
MUNDS PARK
MORMON LAKE
PAULDEN
SIMMONS
NATIONAL
Woodchute Wilderness
CLARKDALE
JEROME
COTTONWOOD
PAGE SPRINGS
CHINO VALLEY
BRIDGEPORT
CORNVILLE
HAPPY JACK
Granite Mountain Wilderness
McGUIREVILLE
Wet Beaver Wilderness
MONTEZUMA CASTLE NATIONAL MONUMENT
IRON SPRINGS
FOREST
CAMP VERDE
PRESCOTT
West Clear Creek Wilderness
Fossil Springs Wilderness
DEWEY
NATIONAL
MAYER
Cedar Bench Wilderness
DUGAS
FOREST
CORDES JUNCTION
CORDES
TONTO VILLAGE
KOHLS RANCH
CROWN KING
HORSETHIEF BASIN
Castle Creek Wilderness
Black Mesa
CONSTELLATION
ROCK SPRINGS
BLACK CANYON CITY
Mazatzal Wilderness
JAKES CORNER
CASTLE HOT SPRINGS
WICKENBURG
SEVEN SPRINGS
TONTO
MORRISTOWN
LAKE PLEASANT
CAVE CREEK
CAREFREE
SUNFLOWER
CIRCLE CITY
WITTMANN

NOTES

MAP 14


Quartzsite
Julian Mine
Granite Mtn
Cholla Road
OLD YUMA RD
PIPELINE
LA PAZ VALLEY RD
Yum Yum Mine
Eightmile Well
L A P O S A
4WD
250
277
297
300
302
322
LP267
LP255
LP257
LP232
LP321
LP252
LP253
LP274
LP256
LP275
LP254
LP251
LP231
LP233
LP273
LP234
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LP225
LP570
LP585
LP419
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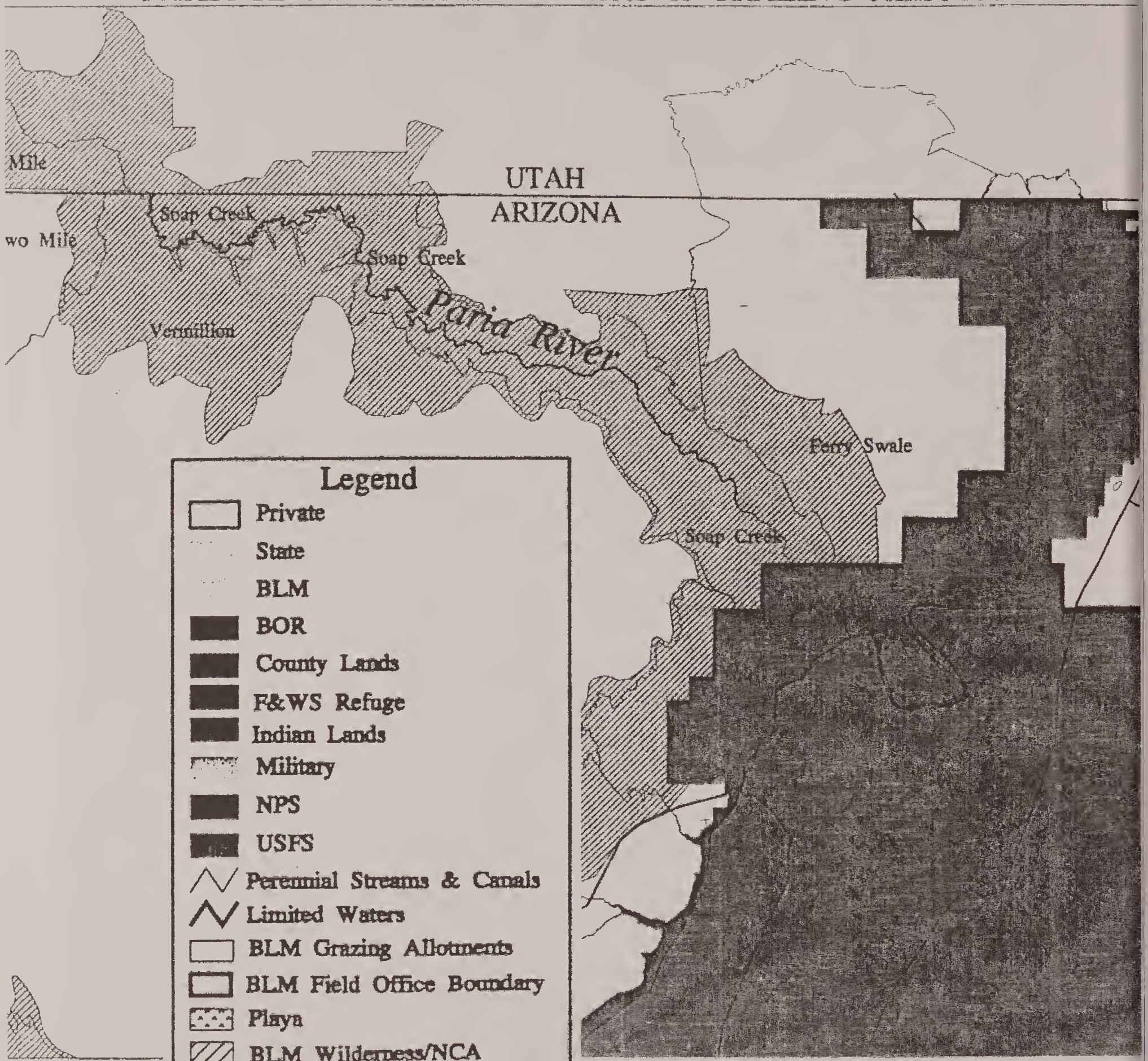
LP491
LP397
LP400
LP402
LP404
LP403
LP619
LP392
LP391
LP393
LP394
LP561
LP547
LP223
LP224
LP545
LP543
LP544
LP542
LP580
LP575

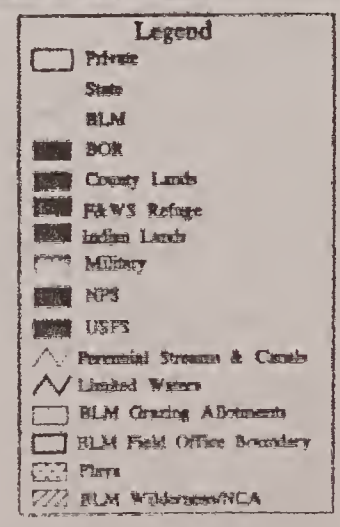
NOTES

MAP 15

NOTES

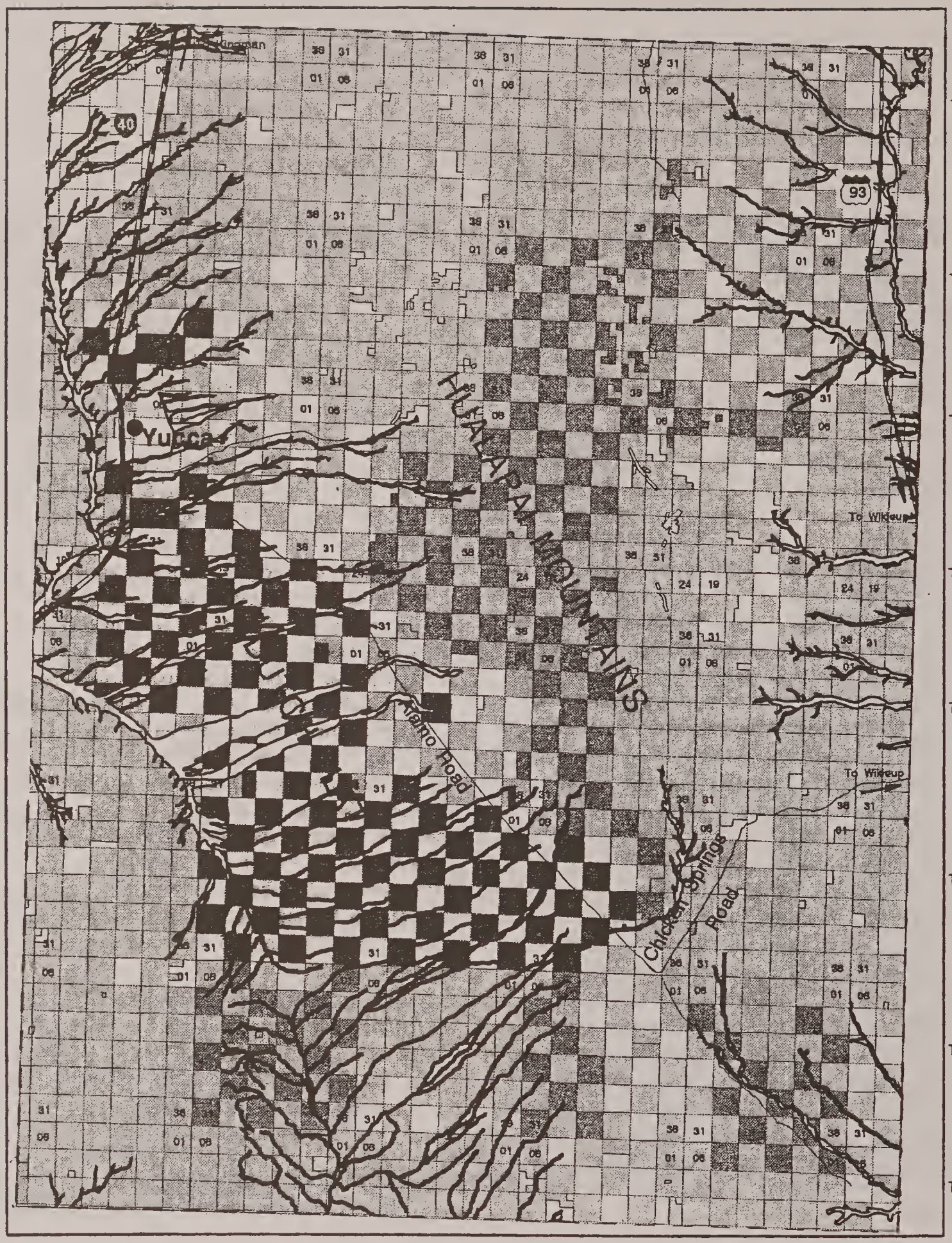
PARIA RIVER LIMITED WATERS & GRAZING ALLOTMENTS





NOTES

Map 7. FEMA Flood Plain Data



LEGEND

- Q3 Flood Data SFHA zone
- Offered/Private Land
- Selected/Public Land
- Public Land
- State Land
- Private Land
- Penstemon ACEC Boundary
- Wilderness
- Major Road
- Secondary Road

Hualapai Mountain Exchange

NOTES

MAP 18

NOTES

Shaded Relief Map of Colorado

Data Sources
Relief: USGS 3 Arc-second DEMs
Highways: Colorado DOT
Towns & Cities: DCW
F.O. Boundaries: BLM

Map Legend

- Cities
- Towns
- Interstate Highways
- Other State Highways
- Field Office Boundaries

- Above 12,000
- 11,500' - 12,000'
- 11,000' - 11,500'
- 10,500' - 11,000'
- 10,000' - 10,500'
- 9,500' - 10,000'
- 9,000' - 9,500'
- 8,500' - 9,000'
- 8,000' - 8,500'
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- 6,000' - 6,500'
- 5,500' - 6,000'
- 5,000' - 5,500'
- 4,500' - 5,000'
- 4,000' - 4,500'
- 3,500' - 4,000'
- 3,000' - 3,500'

Colorado State Office
Resource Services

January, 1999

N W E S

10 0 10 20 30 40 50 Miles

Kremmling

Glenwood Springs

Gunnison

San Luis

Royal Gorge

NOTES

Field Office Boundary
6 Mile Buffer of F.O.
Township/Range Lines
BLM Lands

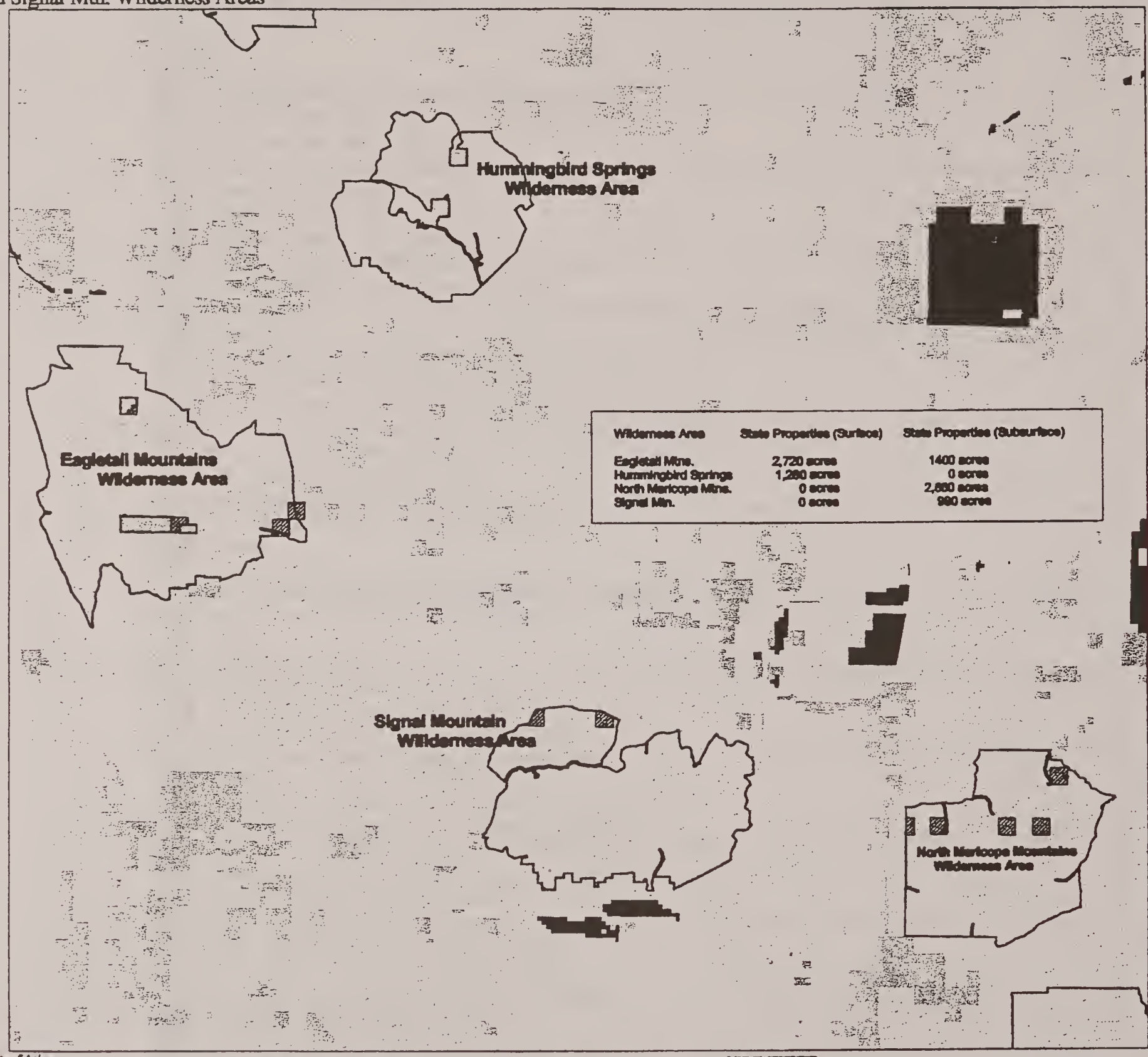
Gapveg

Agriculture
Chihuahuan Creosotebush-Tarbush Scrub
Chihuahuan Mesquite Shrub Hummock
Chihuahuan Mixed Scrub
Chihuahuan Whitethorn Scrub
Douglas Fir-Mixed Conifer
Encinal Mixed Oak
Encinal Mixed Oak-Mesquite
Encinal Mixed Oak-Mexican Mixed Pine
Encinal Mixed Oak-Pinyon-Juniper
Encinal Mixed Oak/Mixed Chapparal/Semidesert Grassland-Mixed Scrub
Industrial
Int. Chaparral (Mixed)/Son. Paloverde-Mixed Cacti
Int. Chaparral-Mixed Evergreen Sclerophyll
Int. Chapparal (Mixed)/Mixed Grass-Scrub Complex
Int. Chapparal-Shrub Live Oak-Pointleaf Manzanita
Int. Riparian/Cottonwood-Willow Forest
Int. Riparian/Mesquite Forest
Int. Riparian/Mixed Broadleaf Forest
Int. Riparian/Mixed Riparian Scrub
Mixed
PJ (Mixed)/Mixed Chapparal-Scrub
PJ-Shrub/Ponderosa Pine-Gambel Oak-Juniper
Pinyon-Juniper-Mixed Grass-Scrub
Playa
Ponderosa Pine
Ponderosa Pine-Mixed Conifer
Semidesert Mixed Grass-Mesquite
Semidesert Mixed Grass-Mixed Scrub
Semidesert Mixed Grass-Yucca-Agave
Semidesert Tobosa Grass-Scrub
Son. Riparian/Cottonwood-Mesquite Forest
Son. Riparian/Cottonwood-Willow Forest
Son. Riparian/Leguminous Short-Tree Forest/Scrub
Son. Riparian/Low-lying Riparian Scrub
Son. Riparian/Mesquite Forest
Son. Riparian/Mixed Broadleaf Forest
Son. Riparian/Mixed Riparian Scrub
Son. Riparian/Sacaton Grass Scrub
Son./Chih. Riparian/Reed-Cattail Marsh
Sonoran Creosotebush Scrub
Sonoran Creosotebush-Bursage Scrub
Sonoran Creosotebush-Bursage-Paloverde-Mixed Cacti (wash)
Sonoran Creosotebush-Mesquite Scrub
Sonoran Paloverde Mixed Cacti/Sonoran Creosote-Bursage
Sonoran Paloverde-Mixed Cacti-Mixed Scrub
Sonoran Paloverde-Mixed Cacti/Semidesert Grassland-Mixed Scrub
Sonoran Saltbush-Creosote Bursage Scrub
Urban
Water

NOTES

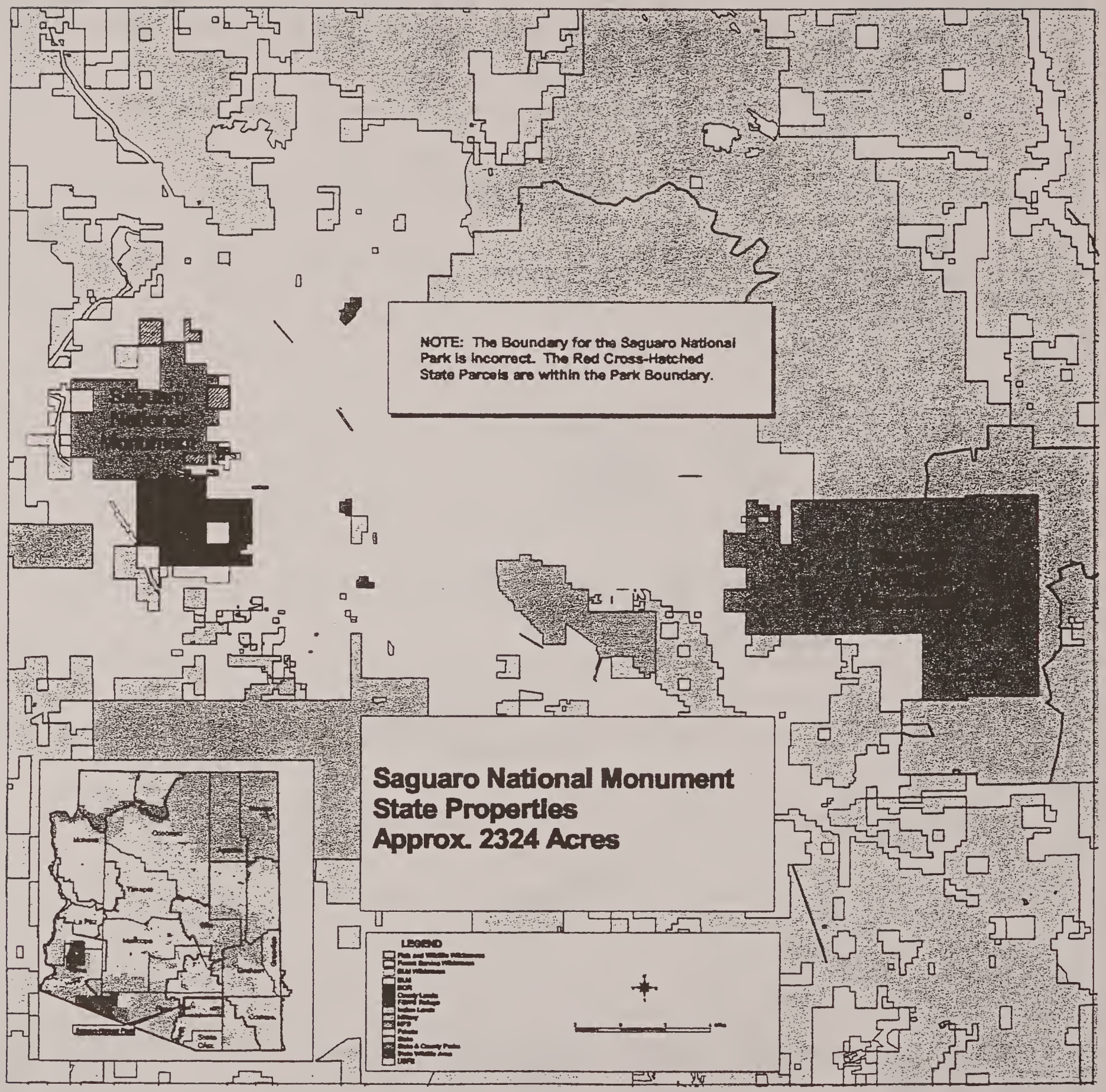
Eagletails Mtns., Hummingbird Springs, North Maricopa Mtns., and Signal Mtn. Wilderness Areas

State of Arizona
Surface Management Responsibility - Custom 1:130,000 Scale



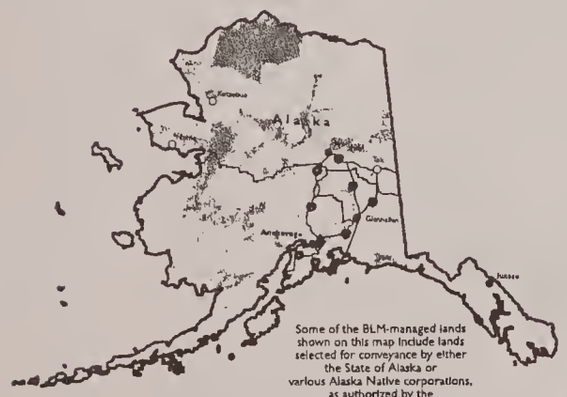
Wilderness Area	State Properties (Surface)	State Properties (Subsurface)
Eagletail Mtns.	2,720 acres	1400 acres
Hummingbird Springs	1,280 acres	0 acres
North Maricopa Mtns.	0 acres	2,880 acres
Signal Mtn.	0 acres	960 acres

NOTES


NOTE: The Boundary for the Saguaro National Park is incorrect. The Red Cross-Hatched State Parcels are within the Park Boundary.
Saguaro National Monument
State Properties
Approx. 2324 Acres
LEGEND

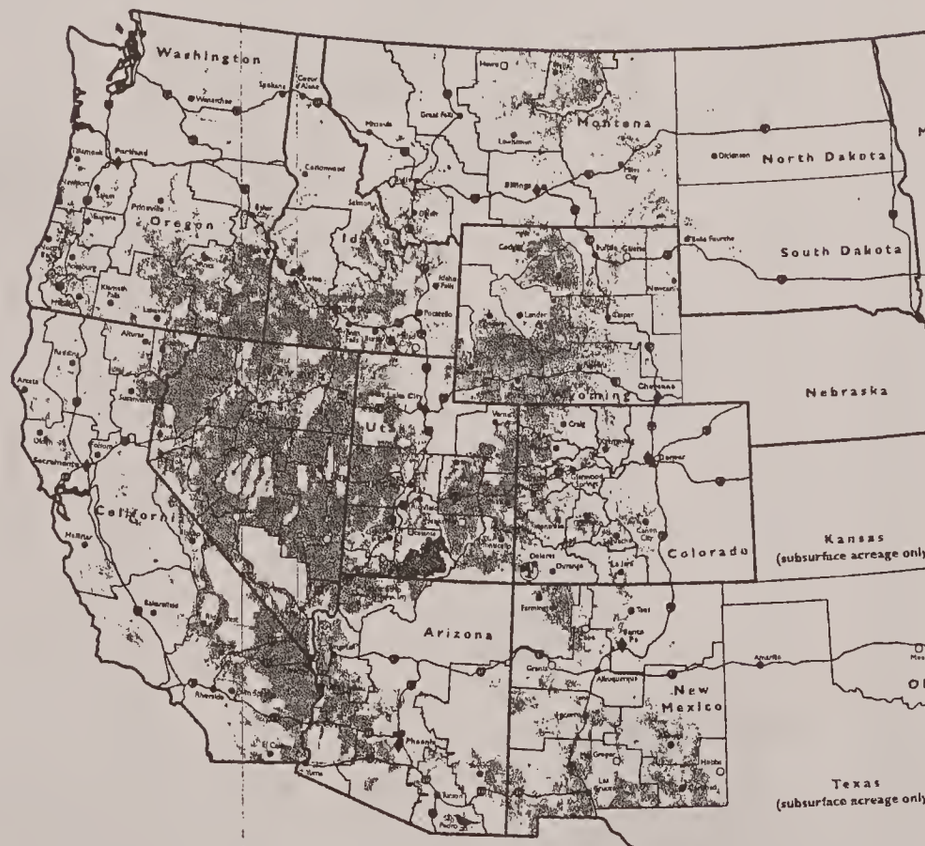
NOTES

Public Lands Managed by the Bureau of Land Management (BLM)



Some of the BLM-managed lands shown on this map include lands selected for conveyance by either the State of Alaska or various Alaska Native corporations, as authorized by the Alaska Native Claims Settlement Act and other legislation.

- BLM-Managed Lands
- BLM Headquarters
- BLM State Office Locations
- BLM Field Office Locations
- BLM Field Station Locations
- BLM National Training Center
- BLM National Centers
- Yaquina Head Outstanding Natural Area Interpretive Center
- National Interagency Fire Center
- National Historic Oregon Trail Interpretive Center
- Anasazi Heritage Center
- San Pedro Riparian National Conservation Area Project Office
- BLM State Office Jurisdictions
- BLM Field Office Boundaries
- State Boundaries
- Major Highways
- Grand Staircase-Escalante National Monument



The Montana State Office has jurisdiction over BLM-managed land in North and South Dakota. The New Mexico State Office has jurisdiction over BLM-managed land in Oklahoma, Kansas, and Texas. The Oregon State Office has jurisdiction over BLM-managed land in the State of Washington. The Wyoming State Office has jurisdiction over BLM-managed land in Nebraska.

In the Eastern United States, the BLM manages 39.7 million acres of subsurface mineral estate and 30,000 acres of surface, mostly small isolated parcels scattered throughout 31 States.

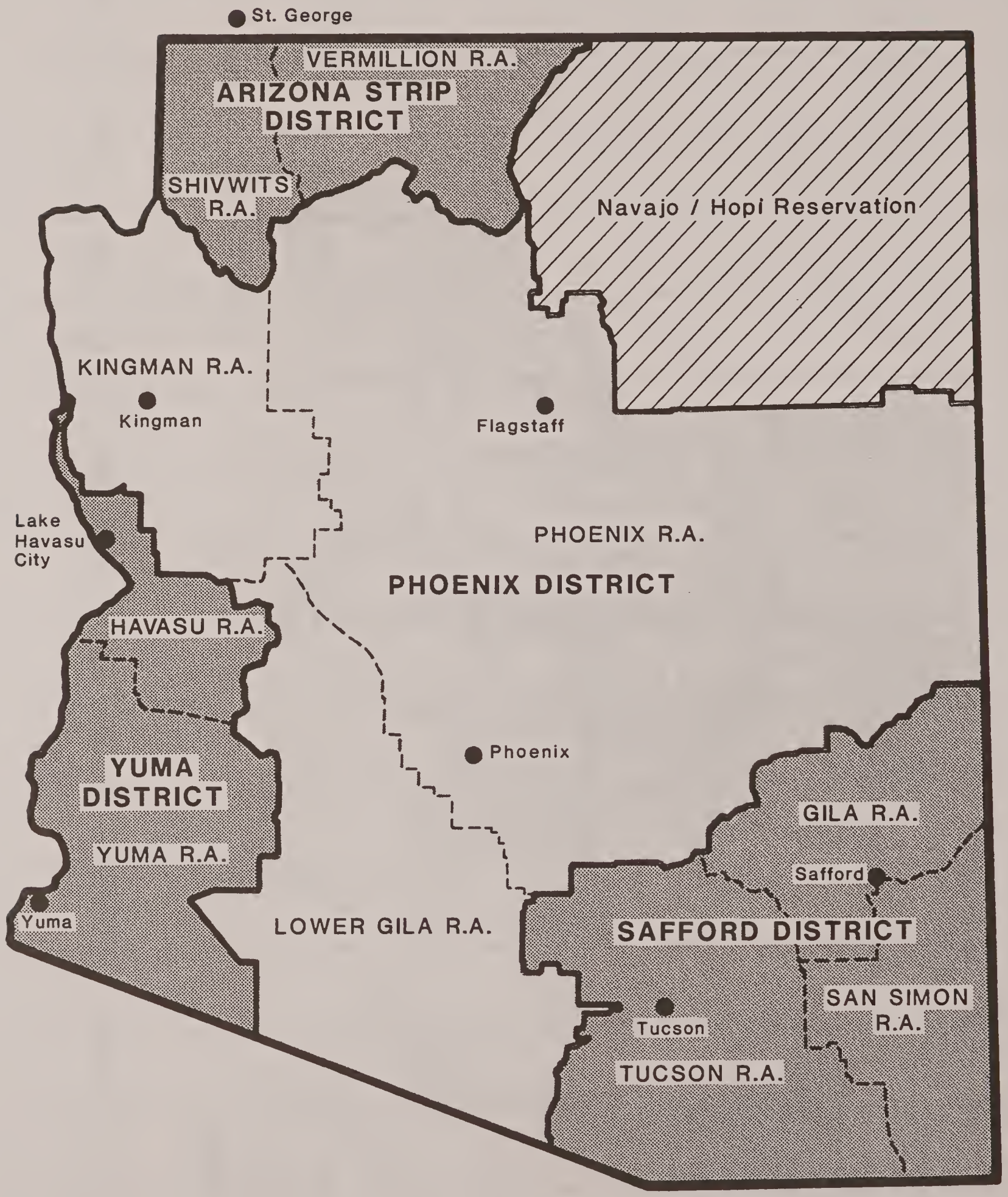
Eastern States are administered by the Eastern States Office in Springfield, VA.

Today, the BLM administers 264 million acres of public lands located primarily in the 12 Western States, including Alaska.

The agency manages an additional 300 million acres of subsurface mineral estate located throughout the country.

NOTES

ARIZONA BLM DISTRICT AND RESOURCE AREA BOUNDARIES



NOTES

SAN PEDRO HOUSE TRAIL SYSTEM

LEGEND

- Information
- Parking Lot
- *Wash*
- Trail
- Old Road Bed

NOTE: Trails and old road beds are closed to vehicle traffic.

N

Linear Pool

Old Road Bed

Railroad

Old Road Bed

Wash

SAN PEDRO RIVER

Old Road Bed

To Tombstone or Bisbee

90

Bridge

Highway 90 Entrance

Entrance Road

Linear Pool

To Sierra Vista

SAN PEDRO HOUSE

Dry Ox Bow (Cottonwood Grove)

Large Cottonwood Tree

Green Kingfisher Pond

Old San Rafael del Valle Road Bed

ARIZONA

PHOENIX

TUCSON

MAP LOCATION

Garden Wash

Black Phoebe Pond

SAN PEDRO RIVER

Railroad

SCALE

0 ½ 1 Mile

0 ½ 1 Kilometer

NOTES

Further Information:

For information concerning site availability, weather conditions, recreation site regulations, or available activities, write to:

Bureau of Land Management
Phoenix District Office
Kingman Resource Area
2475 Beverly Avenue
Kingman, Arizona 86401
or phone: (602) 757-3161

BLM-AZ-AE-92-007-8300

U.S. Department of the Interior
Bureau of Land Management

Phoenix District Office

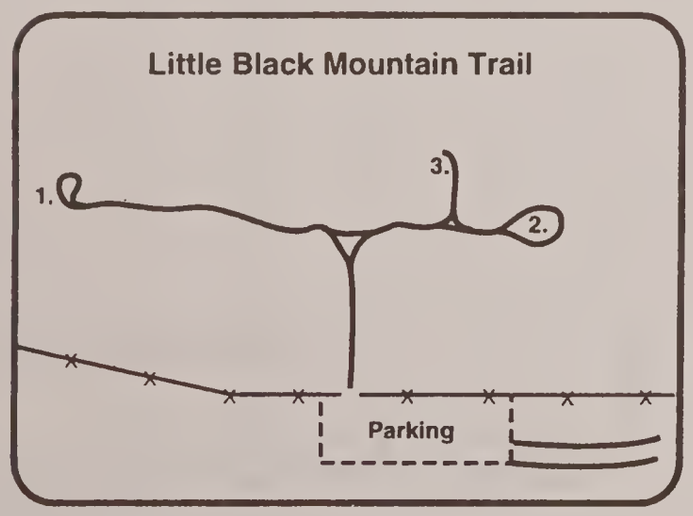
Burro Creek Recreation Site

ARIZONA

NOTES

What do they mean?
Scientific study and comparisons to modern Native American art allows us to guess what some of the petroglyphs may signify. Based on age and stylistic differences, we know that different cultures made them.

Petroglyphs represent the artistic nature of a people long gone and meanings long forgotten. One fascination of petroglyphs is that they mean different things to each individual. You are welcome to make your own interpretation of these ancient rock art figures. A general description of three of the most prominent rock art panels follows.



Trail Guide

Stop #1.
This is the largest petroglyph panel at Little Black Mountain. Close examination shows that people from at least three different periods produced these petroglyphs. Individuals from the Archaic and early Anasazi (Basketmaker) cultures, 5,000 to 1,400 years ago, made the petroglyphs that are barely visible today. Late Anasazi people (700-1200AD) probably made the more distinct glyphs.

You may notice some of the more recent glyphs overlie older designs. The placement of one glyph over another may be an attempt to remove or assume the power of the underlying glyph. The large upside-down bird figure may represent a hummingbird. The long line may be a depiction of a life-line from someone's vision quest. The vertical line with the circle may portray access to the spirit world.

Regardless of the culture that made them, most of the glyphs seem to relate to life, death or communication with gods or spirits. Some of the glyphs may represent specific seasonal, agricultural or coming-of-age events. Others may be astronomical symbols and represent calendar or other specific activities.

The large rock to the left also has many older glyphs on it. Many of these are hard to see unless the sun is in the right location. Look closely at the lichens and you will see some growing inside sheep and spiral petroglyphs.

Stop #2.
The petroglyphs on this rock may have a timekeeping function. The majority of the glyphs seem to relate to the seasons, astronomy or time as shown by the spirals and two calendar glyphs. One human figure and possibly a second have horns, which is a common depiction of a shaman or medicine man. The animals and insects may be symbolic messengers. Here you see at least four different styles from Archaic through Anasazi periods. This panel represents a time span of about 6,000 years. The word ZENO is an example of historic defacement.

Stop #3.
This rock panel contains many sheep figures of the same style. Footprint depictions may be shaman signatures. These glyphs may be symbols for good luck on a hunt or other messages. The upside-down human figure may be telling of a death, possibly a hunting accident.

Hunting and gathering people of the Archaic and Basketmaker cultures made the older glyphs.

Petroglyphs on other rocks probably represent isolated events. Please respect this place of the "ancient ones" by taking nothing but pictures and leaving nothing but footprints.

For more Information

Bureau of Land Management
Shivwits Resource Area
225 N. Bluff Street
St. George, UT 84770
Phone: (801) 628-4491

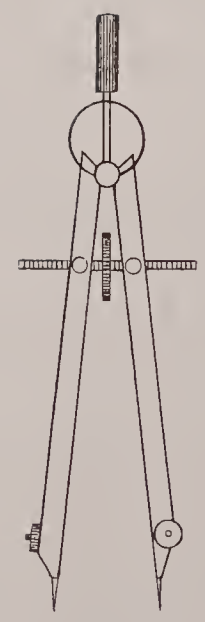
Arizona Strip District Office
390 North 3050 East
St. George, UT 84770
Phone: (801) 673-3545

See also the BLM Arizona Strip Visitor's Map.

The BLM expresses its thanks to the Dixie Chapter of the Utah Statewide Archaeological Society, Technical Services, the BLM fire crew and individuals who have contributed many hours of volunteer effort to the development of this site.

BLM/AZ/GI-94/002+8300

NOTES



MAP ELEMENTS

TITLE

Practically all maps, whether they are stand-alone displays or part of a series in a publication, need a title. The title enables the reader to ascertain, at a glance, the subject matter of the map. It should be the most prominent text on the map and be as brief as possible, yet express accurately what the map was designed to communicate.

LEGEND*

The map legend is used to explain what is shown on the map. It is the location where the reader obtains the basic information for interpreting the material presented there. Generally, the legend displays point, line, and area symbols. It is important that the text narration that accompanies these symbols is as accurate and descriptive as possible. It is also vital that the reader be able to differentiate between various similar-looking symbols. For example, a series of lines showing different types of roads must be easy to tell apart (using various solid line thicknesses, dashed lines, dot-dash lines, etc.). Likewise, area symbols using grey tones or colors must have enough difference between them to be easily distinguishable. Finally, the symbols used in the legend and on the map should be of the same size and boldness in line weight. This avoids confusion on the reader's part, when symbols look different between the legend and map.

In general, the legend is the guide to the map. It should assist the map in "standing alone" as much as possible (see Essay 1) and must be very clear and understandable in its meaning.

* On older maps where there was a very small legend, it was sometimes labeled as the "Key." However, this term is used very rarely today.

SCALE

All maps need scales! Without a scale the reader has no idea of the size of the area shown on the map. There are certain rare cases where, for unique reasons, a map may be designed without a scale (these are usually for special purpose graphic products). However, the vast majority of maps must have a scale included.

Generally, there are three ways to designate a scale.

(1) The unit comparison method: An example of this would be the statement on the map: "1 inch equals 1 mile," or "1 inch equals 100 miles," or "1 centimeter equals 500 kilometers." While a very understandable technique, this is not a good choice. You have to have a measuring device available (a ruler, centimeter scale, etc.) and there may be confusion over the units used. Worse, any change in map size (enlargement or reduction) makes the scale absolutely incorrect.

(2) The proportion method: This is the procedure used by professional cartographers in their work and would appear on the map as, for example, 1:63,360, or 1:250,000, or 1:1,000,000. (In the first case, this means 1 unit – of any type – on the map equals 63,360 units of the same type on the ground. Thus, 1 inch on the map equals 63,360 inches on the ground.) While this proportion technique has great significance to cartographers, it means little to the average person who does not understand it. Also, this approach suffers from the same problem as the previous one: a size change – even a very small one – makes it incorrect. Thus, it is not recommended except in combination with number (3) below.

(3) The bar scale method: This process uses a graphic bar or rake scale to indicate distances on the map. This is the best way to show map scale. It is easily understood by most readers and is the only one of the three methods to show accurate distances if the map is enlarged or reduced (since the bar enlarges or reduces *with* the map). When showing the scale bar on the map it is recommended to use two bars side-by-side, one for English units and one for metric units (miles and kilometers, for example) so that all map users are adequately served.

LOCATION DIAGRAM

The location diagram shows the position or context of the map within the larger geographical region which it occupies. In this way it aids the reader in not only understanding *where* the map is located, but also in comprehending how much *area* is covered by it. Location diagrams are especially important on "large-scale" maps, where the territory covered is relatively small. They should be as simple and easy to read as possible. For example, a location diagram that includes the map site and one or two nearby cities, or a couple of major highways, is often sufficient. Clarity is the key here.

NORTH ARROW

The north arrow may or may not be necessary for inclusion on a map. Most maps are oriented with north at the top and this is generally understood by the public. Thus an arrow is not absolutely needed on these maps. One may be included, but only if it does not clutter the map, making it harder to read. However, on any maps where north is not at the top of the page, a north arrow is "mandatory."

In design, north arrows should be kept relatively simple. Those that are too complex may take up too much valuable space, be hard to read, and may draw attention away from more important elements of the map that the reader should be concentrating on. As with many map design factors, simplicity and clarity are best.

COORDINATES

For more detailed maps, a coordinate system should be included around the outer map boundary or neat line. Latitude and longitude could be used or (very appropriately for BLM maps) township and range divisions. There is also nothing wrong with using both of these coordinate systems on a map at the same time.

ORGANIZATION LOGO

The organization logo (BLM logo) may be placed on the map – usually somewhere on the outside of the map where there is space for it. Care should be taken not to make the logo too large; it should inform the reader but not overwhelm the information on the rest of the map. If there is already an organization text identifier (there should be) and there is not adequate room for the logo, it should be omitted.

ORGANIZATION INFORMATION

Including information about the organization responsible for the creation of the map may be appropriate, especially if it is going to be used in a "stand-alone" manner (for instance, as a single page handout or a display map). An example of this would be:

U.S. Department of the Interior
Bureau of Land Management
Arizona State Office
Engineering & Mapping Sciences Group

The use of a logo (or logos) serves somewhat the same purpose, so the inclusion of both could be considered redundant. However, since logos are often printed small in size – and therefore hard to read – it may be advisable to use both the text information and the logo.

Cryptic GIS information used in the construction of the map should be avoided as it is not generally understood by the average reader and may cause confusion. If it must be included, it should be placed in a bottom corner of the map in *small text* (6 point size is recommended – see Appendix III).

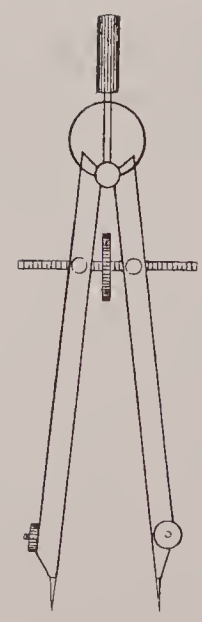
DISCLAIMER

Two things should be said about a disclaimer on a map: (1) if it is needed it is "mandatory" to include it and (2) by including it we are (at least to some degree) admitting to a failure of the map. A map should be accurate. However, if for some reason beyond the cartographer's control there is questionable data being presented, the reader *must* be informed of this in a disclaimer. This really is a failing of the map since inaccurate information is being conveyed. It is the cartographer's responsibility to make sure the data used is as correct as possible.

Here is an example of a disclaimer used on a recent map:

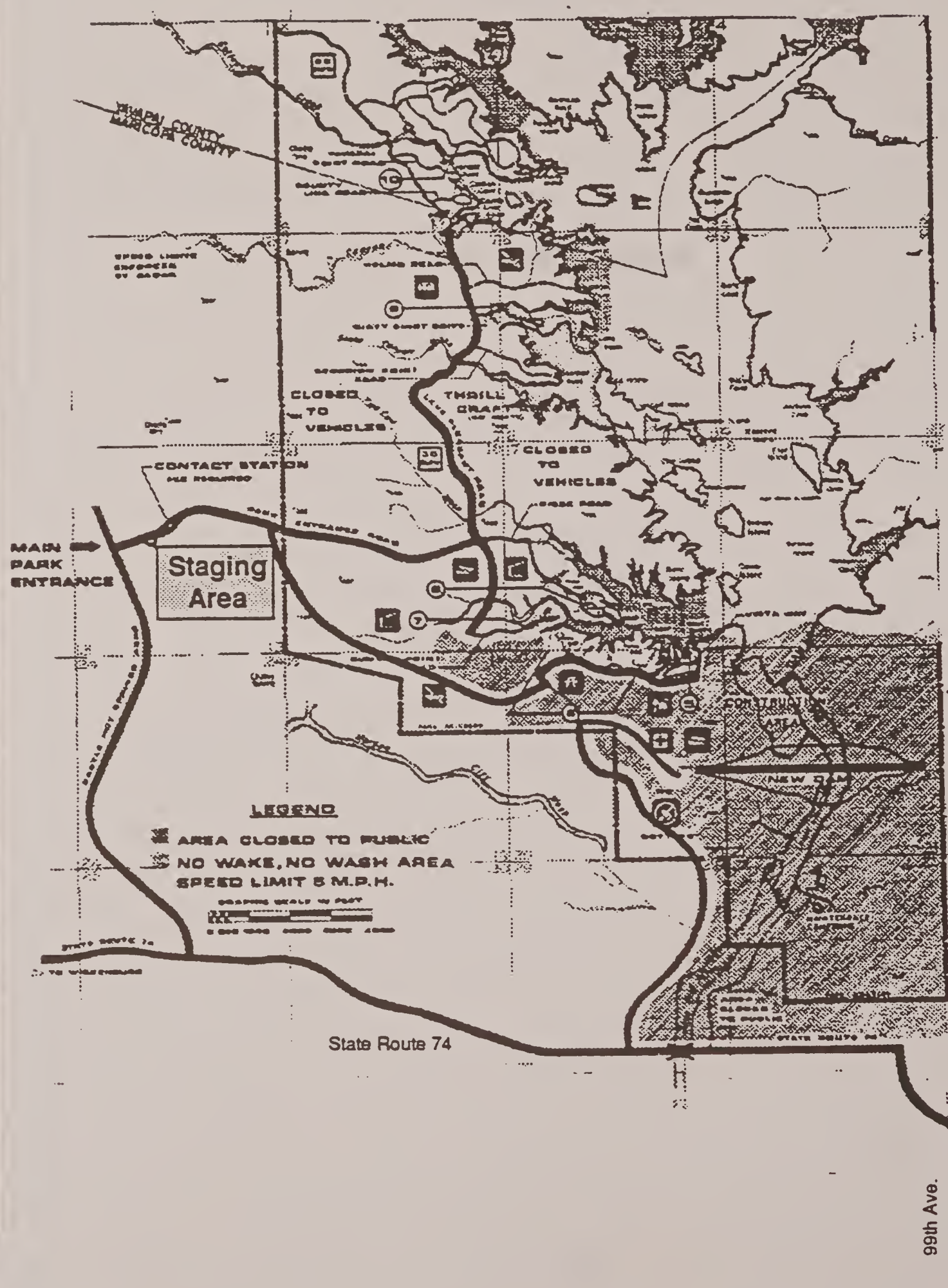
> "The BLM does not guarantee the accuracy, completeness,
> or timeliness of the information shown and shall not be liable
> for any loss or injury resulting from reliance upon the
> information shown."

In other words, the map is not accurate, its information content is only partial, and it is out of date. That kind of makes you wonder why you would use the map at all! The point is, if we are going to make a map to be used, it needs to be accurate and correct.



MAPS: PART II

LAKE PLEASANT ADOPT-A-SHORE

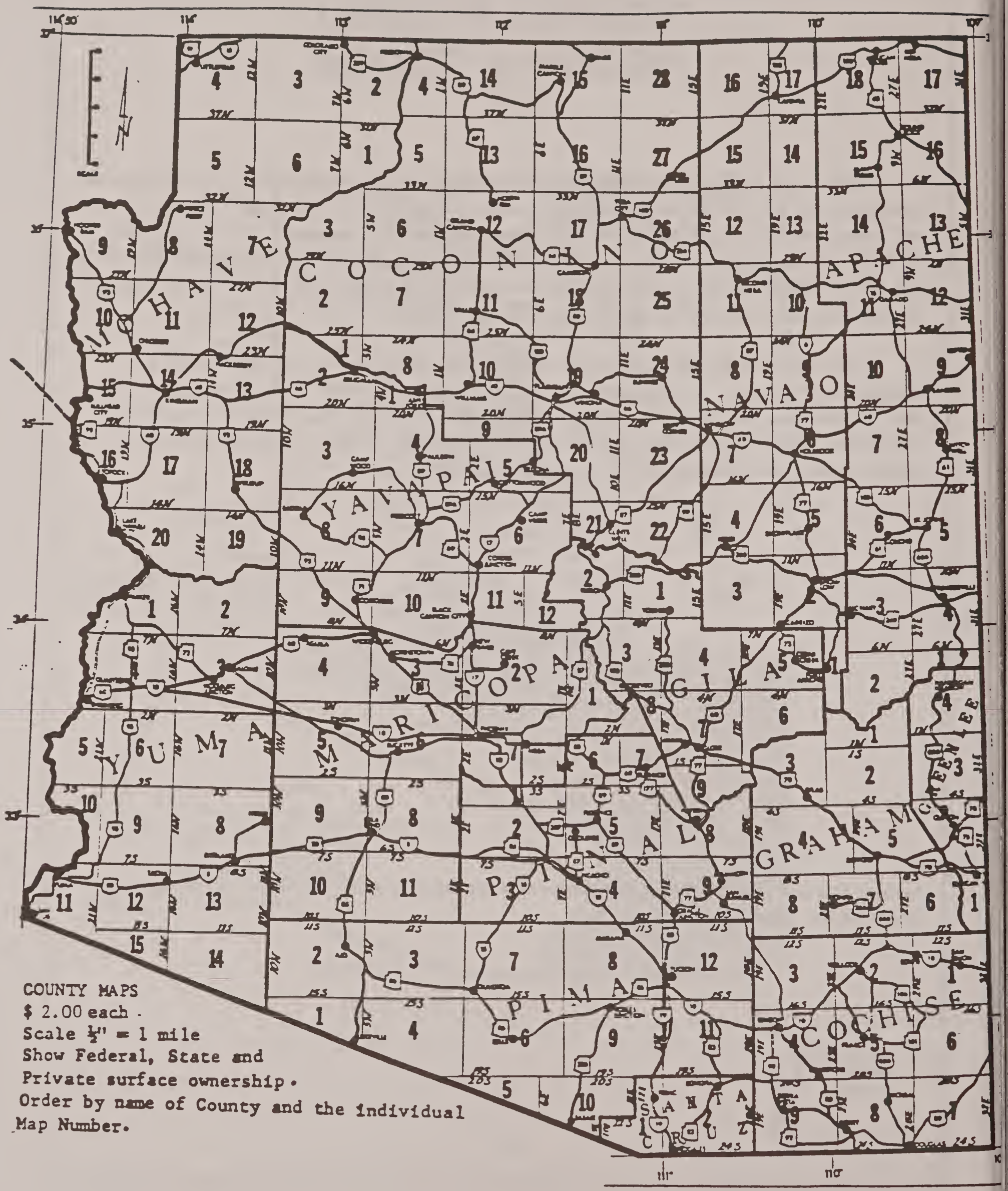


MAP 1

Map 1 was originally used as a "flyer" to be distributed as individual sheets. It is of very poor quality because it is basically unreadable. (1) Practically all of the text is too small in size to be understandable. (2) It is difficult to follow the lake shore boundary, especially along the west side. (3) The areas in the legend are hard to follow on the map. Also, the recreation symbols shown on the map are not explained in the legend. (4) There is a scale bar but, again, it is too small to be readable. (5) A location map would have been helpful, for those who are not familiar with this area.

This map is an excellent example of what happens when a base map – created at a considerably larger size – is reduced excessively, for a new use for which it was not designed. The text, and other components of the map, become too small to be seen. The map fails because it is unreadable. Since it is unreadable, it is also not understandable. It may be accurate but since we essentially can't see it, that doesn't do the reader any good.

Lessons Learned: The text and other features of a map must be of a readable size for the map to be successful. (See Appendix III.)



COUNTY MAPS
$ 2.00 each .
Scale ½" = 1 mile
Show Federal, State and
Private surface ownership.
Order by name of County and the individual
Map Number.

MAP 2

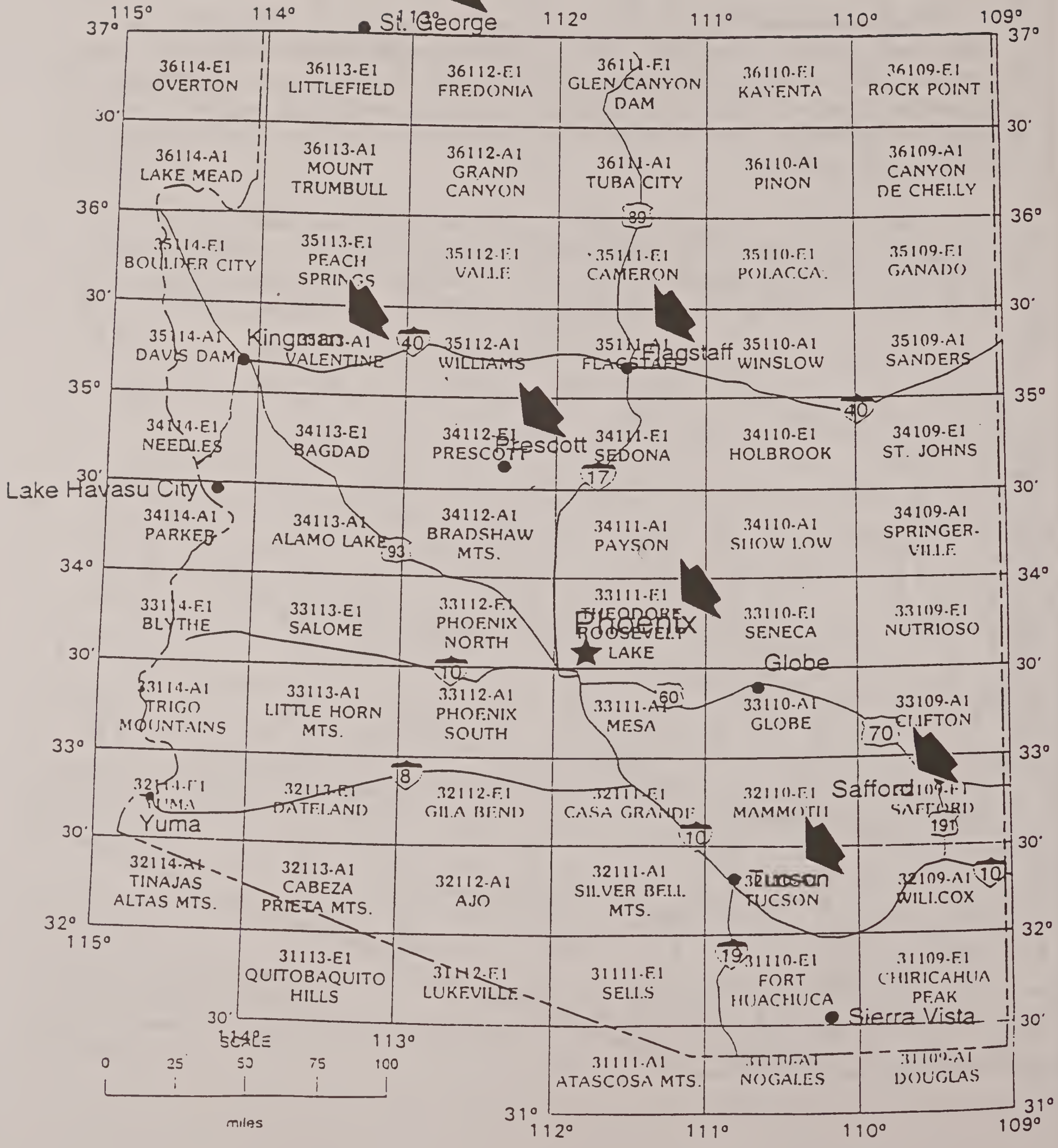
This is a really good example of a really bad map. It was used as a handout guide for the selection and purchasing of other maps. Its major problem is unreadability and lack of contrast. Most of the text is too small to be read (for example, town names and road numbers). Many of the lines are the same thickness (we can't distinguish between county boundaries and roads). In addition, the map legend is confusing about what divisions the larger numbers represent (they are, in fact, *individual pages* of county map atlases).

This map should be totally redesigned. I would recommend including bold county lines, fine county page lines, and numbers for the page maps (the size shown here is OK). The road net and towns can be omitted to simplify the map and make it less congested, and thus more readable. They are not absolutely necessary as that information may be obtained from another appropriate map.

Lessons Learned: Maps must be readable, both in terms of size and in terms of clarity (ie, contrast and lack of congestion).

ARIZONA

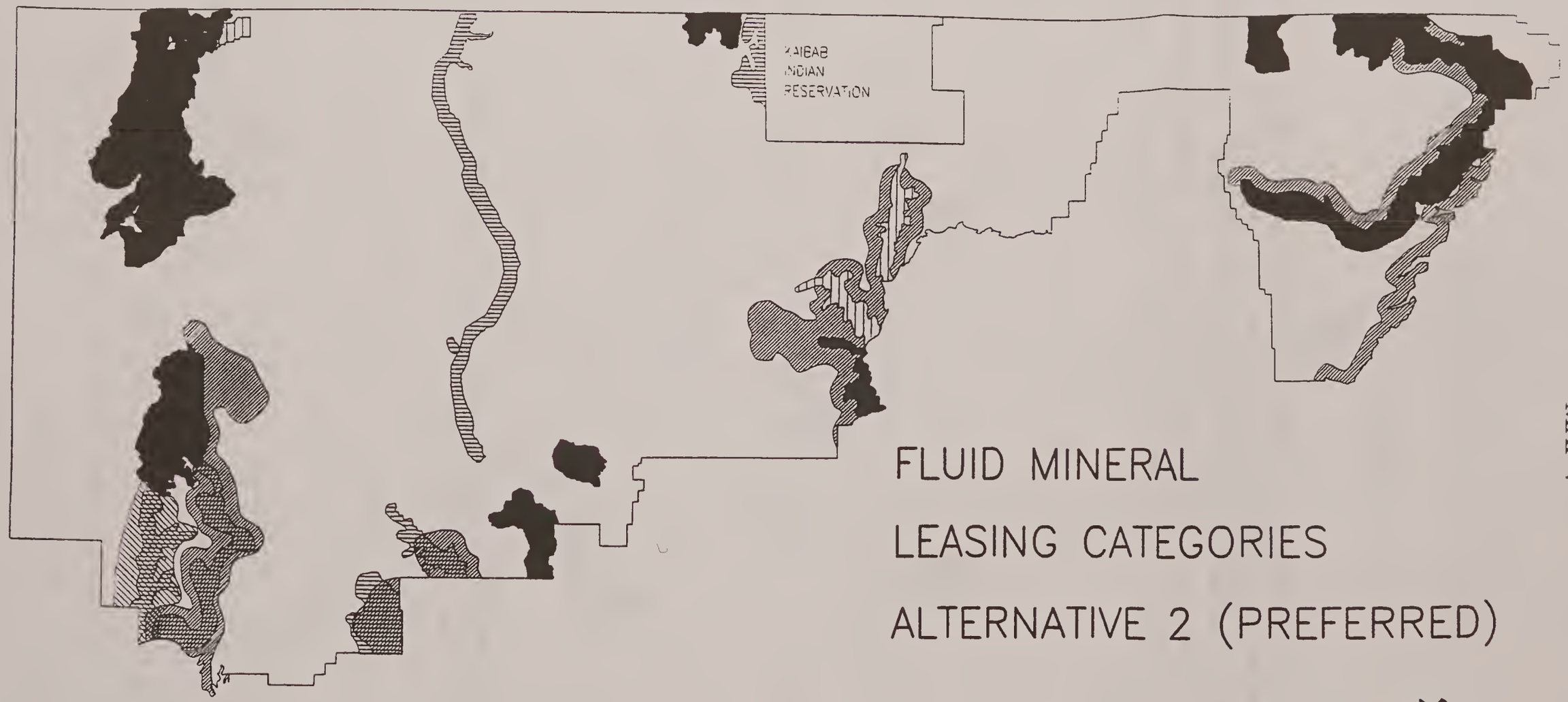
1:100 000 SCALE



MAP 3

This map is a good example of poor map design. Specifically, there are numerous examples where some map text overlays other map text, rendering either (or both) unreadable. The map was used as a handout to show the location of 1:100,000 map coverage of Arizona. It is hard to believe that the overlapping text was not noted and repaired before the maps were made available to the public. A minimal adjusting of a few of the words and this could have been a good map, instead of an embarrassment.

Lessons Learned: All maps should be reviewed by a competent cartographic editor before they are printed and distributed to the public. (See Essay 7.)



FLUID MINERAL
LEASING CATEGORIES
ALTERNATIVE 2 (PREFERRED)

SCALE 1: 500000

N

15.0 0 MILE 15.0

15.0 0 15.0 KILOMETER

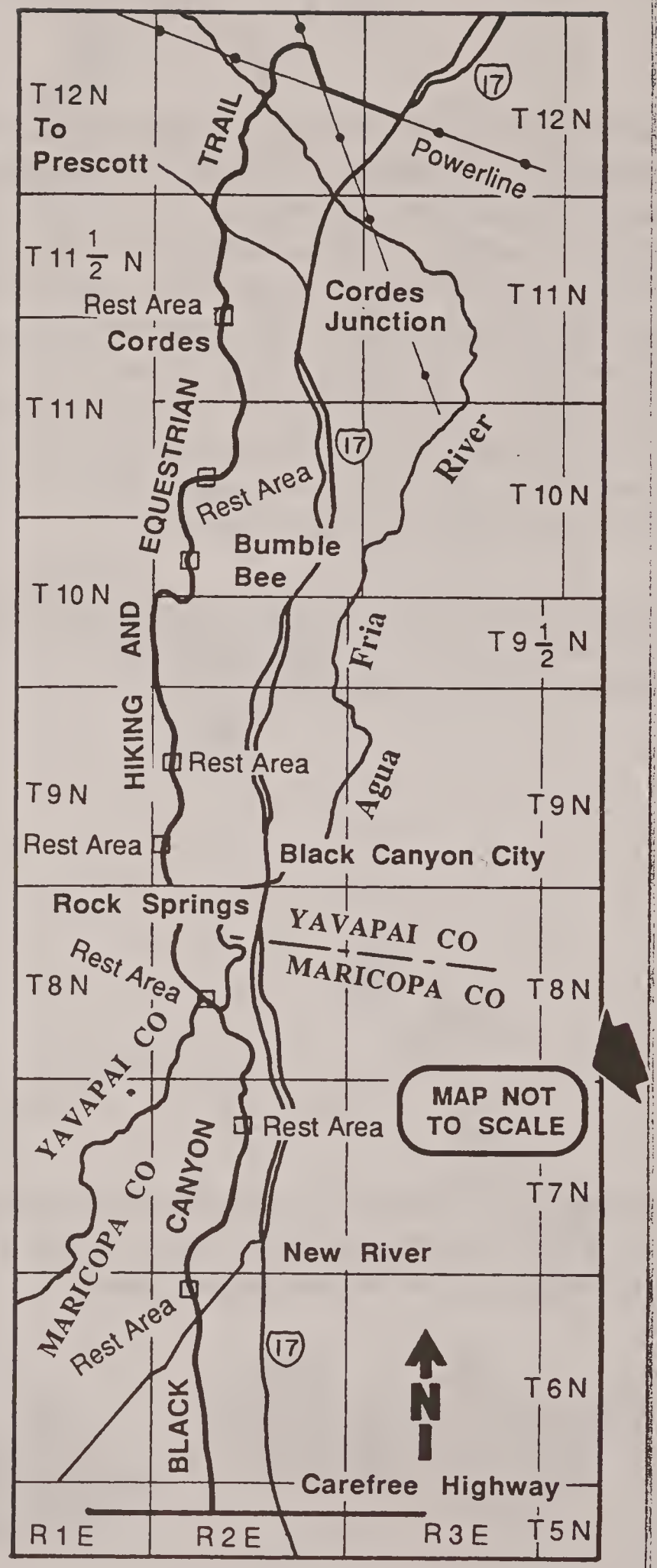
FEATURE	CATEGORY	RESTRICTION	ACREAGE
PEREGRINE	B	OPEN 8/1-3/1	230,000
BIGHORN SH	B	OPEN 6/1-11/30	39,900
VISUAL	C	NSO	23,400
VISUAL	C	NSO SLOPES>30%	114,400
WILDERNESS	D	WITHDRAWAL	265,600

MAP 4

Map 4 was originally designed as a fold-out page in a publication and is reduced to 60% of size here. It was one of a series of maps in the publication designed to this same style and format. There are several odd things about this format. First, the size of the title is very large while all of the other text is very small. There is nothing "in between." A more moderate sized title and larger text on the rest of the map (there is plenty of room for this) would have improved the design. Why is there a large space between the legend boxes and their associated text? Also, a state-wide location map would have been handy. However, the main problem with this map is the lack of specific location information. We have no idea of the relationship of the designated areas, shown as various shading patterns, with anything else. There are no latitude and longitude lines, no township and range grid. There are no highways or villages shown, no streams or mountains. In short, there is nothing on this map to show us where we are located – in relationship to any known coordinates or features.

Consequently, this map is not successful in what it is trying to accomplish. It is readable and may be accurate, but it is not understandable. We cannot relate the areas shown with any known features, so we don't really know where they are located.

Lessons Learned: The items shown on a map must be established by a coordinate system, cultural features (towns, roads, etc.), or physical features (rivers, mountains, etc.) so that the reader has the necessary knowledge of where they are spatially located.


T 12 N
To
Prescott
TRAIL
17
T 12 N
Powerline
T 11 1/2 N
Rest Area
Cordes
Cordes
Junction
T 11 N
T 11 N
EQUESTRIAN
17
River
Rest Area
T 10 N
Bumble
Bee
T 10 N
AND
Fria
T 9 1/2 N
HIKING
Rest Area
T 9 N
Agua
T 9 N
Rest Area
Black Canyon City
Rock Springs
YAVAPAI CO
MARICOPA CO
Rest Area
T 8 N
T 8 N
YAVAPAI CO
MAP NOT
TO SCALE
Rest Area
CANYON
T 7 N
MARICOPA CO
New River
Rest Area
17
N
T 6 N
BLACK
Carefree Highway
R 1 E
R 2 E
R 3 E
T 5 N

MAP 5

This map was part of a brochure on the Black Canyon Hiking and Equestrian Trail. It is somewhat hard to read because of the similarity of the line weights of the various features. I would have recommended a heavy dashed line for the trail, heavy solid line for Interstate 17, a medium-weight line for the Agua Fria River (which should be in italic text, since it is a water feature), and light lines for the township & range lines. The county boundary lines are hard to follow and the small towns (New River, Black Canyon City, Cordes Junction) have no symbols – usually dots are used – to show their locations. The major defect of this map is, however, stated right on it: "Map not to Scale." How can you invite the public to use a hiking and equestrian trail, and then not indicate what distances they will be covering?! Obviously this map needs an accurate scale.

In summary, although this map is fairly readable it fails on the understandable criteria because the reader does not know what distances are involved. Incidentally, this map also failed on the accuracy question since the northern part of the trail had not yet been constructed when the brochure was distributed.

Lessons Learned: <u>All maps</u> need accurate scales.

CURRENT OHV USE

NON-DESIGNATED
LIMITED
LIMITED: ACCESS PERMIT REQUIRED
CLOSED
OHV RACECOURCE

RESOURCE AREA BDY.
MANAGEMENT AREA BDY.
INTERSTATE HIGHWAY
FEDERAL HIGHWAY
STATE HIGHWAY
INTERSTATE HIGHWAYS
PAVED AND MAJOR UNPAVED ROADS

BLM LANDS
BLM WILDERNESS (OUTSIDE LGRA)
BLM WILDERNESS (INSIDE LGRA)
GOLDWATER AIR FORCE RANGE

15 0 15 30 MILES
SCALE

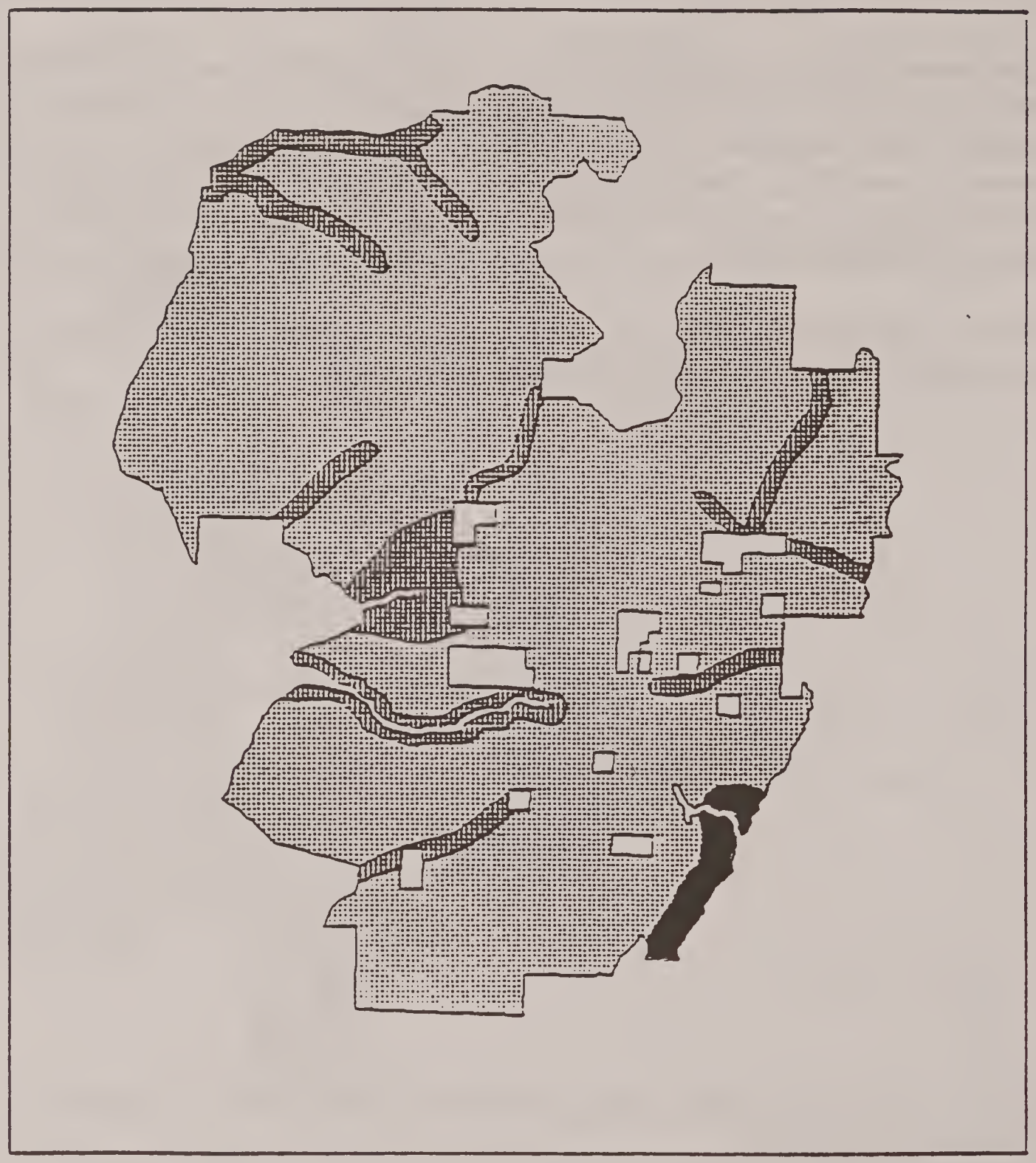
MAP 6

This is another good example of a map that "tries to do too much within the space available." It was originally part of a report. Without going into detail, we can say that it is obvious that the map is overly complex. It has an excessive amount of material shown on it and is reduced in size to a point that approaches unreadability. The result is that lines are cluttered and hard to see, some of the tones are difficult to distinguish, and much of the text is too small to be easily read. A more simplified base and, perhaps, the division of the map into two larger-scale pages would have improved it considerably.

This map, because of its complexity, suffers on the "readability" – and consequently on the "understandability" – criteria (even though it probably is accurate).

Lessons Learned: If a map is overly complex it will not be understandable. It should be simplified as much as possible.

Map 5
Wabayuma Peak Management Zones



UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

N

0 1 2
Miles

LEGEND
- Class I
- Class II
- Class III
- Private Inholdings

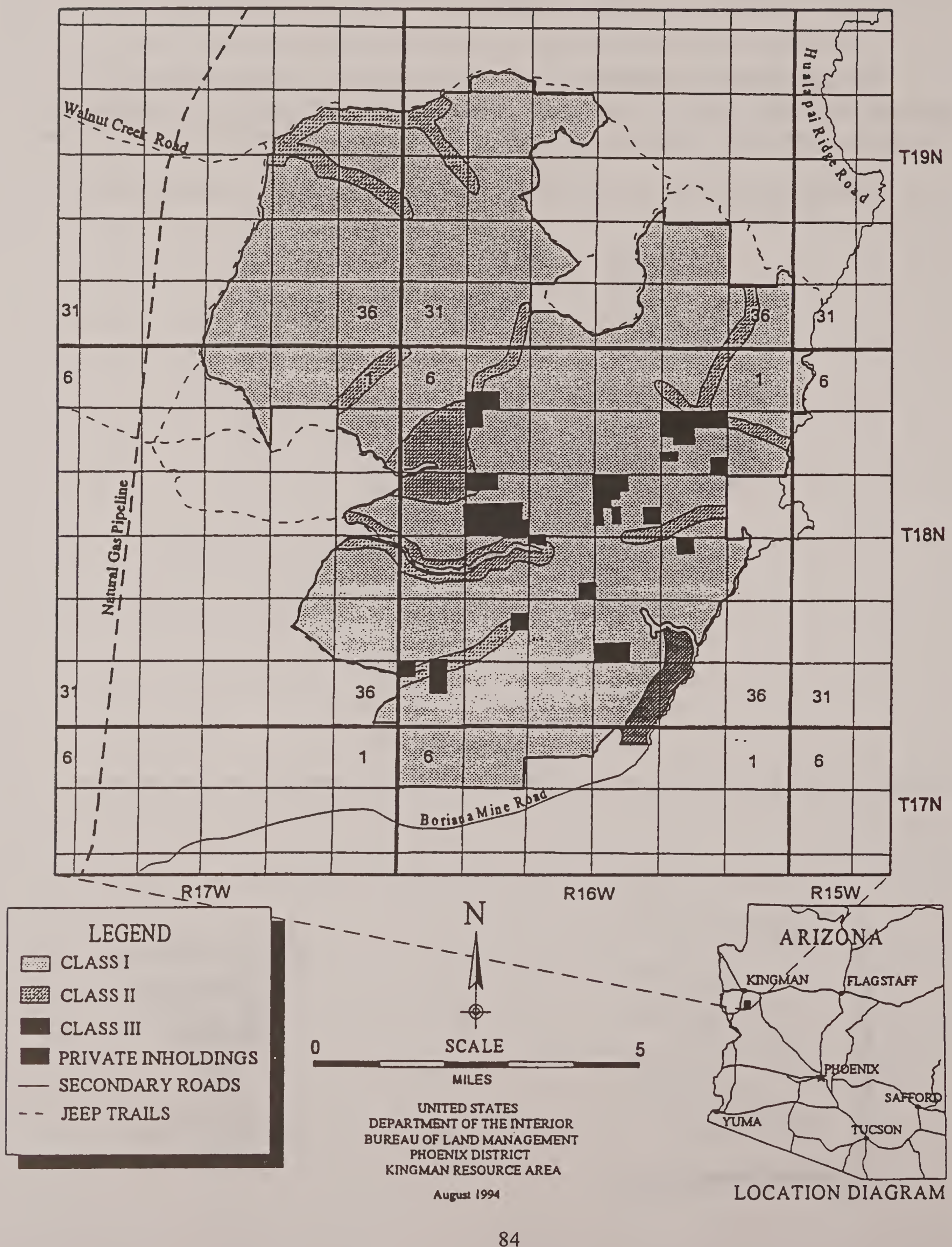
MAP 7

This map was used in a publication. It is a good example of a map that contains too little locational information. There are no coordinates, roads, or any other physical features to show where this area lies. Also, there is not even a location diagram to indicate the site of the map within the state.

After the map was edited, it was modified. See Map 7A for the result. (See also Essay 7.)

Lessons Learned: A map can also show too little data. Basic locational information is required.

Map 5
Wabayuma Peak Management Zones



MAP 7A

This is a redo of Map 7. Note the improvements! Township & range lines, roads, and a pipeline have been added. We now have an understanding of where the various classes (what the map was constructed to display) lie with regard to the geographical base. The location diagram indicates the map site within the state. Even the scale and organization information are better shown. The logo has been omitted but it was not needed here anyway, as the map already lists the responsible organizations. (Although the classes in the legend are not explained, this map is in a document which discusses them elsewhere.)

Lessons Learned: A map requires basic geographical location information.

- **Table Top Trail** - Located 25 miles west of Casa Grande • 2,100 to 4,356 foot elevation • 4.5 miles one way • for hiking and equestrian use • best during late fall, winter and early spring • moderate trail. For more information call (602) 580-5500.

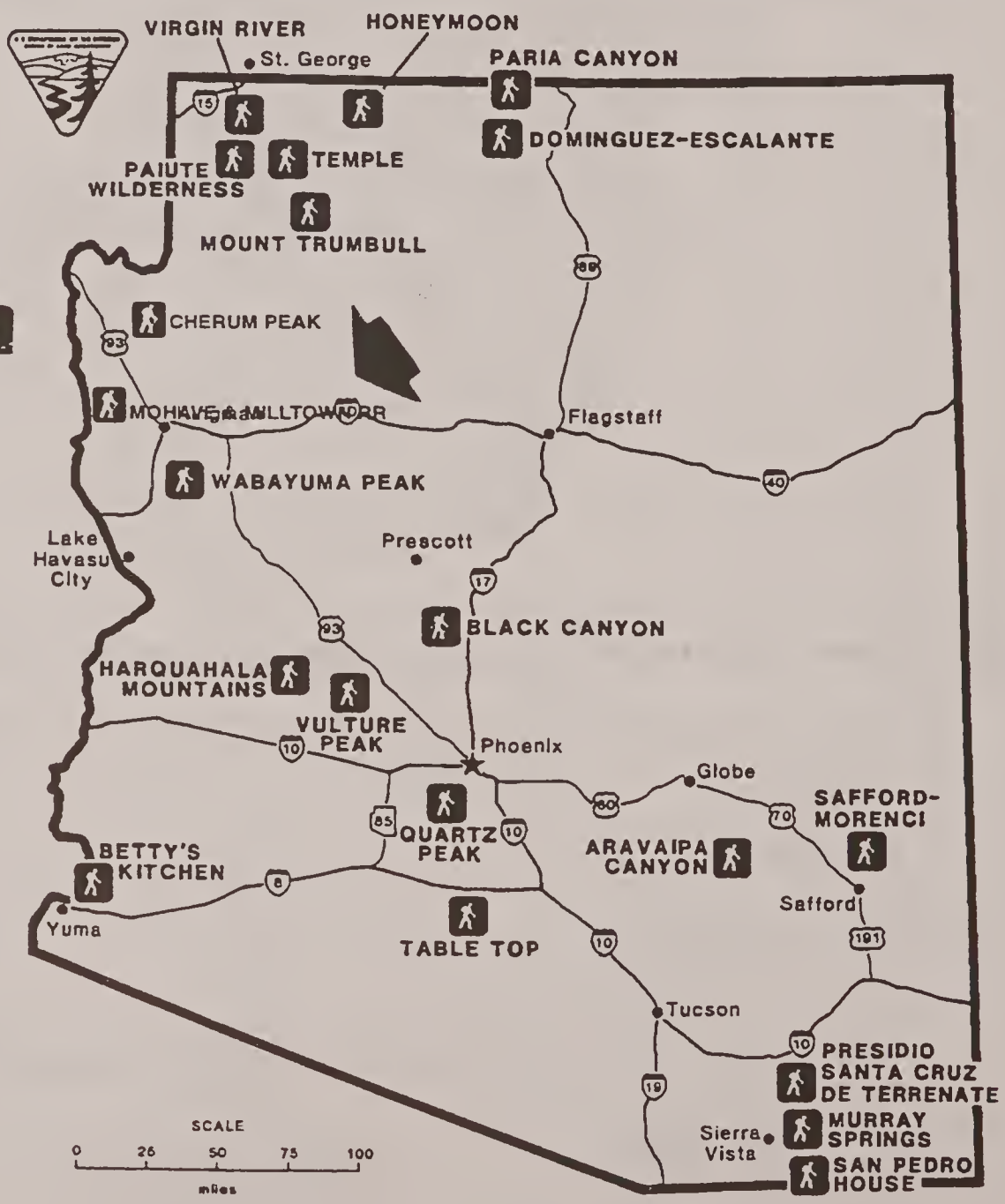
- **Temple Trail** - Located 55 miles southwest of Fredonia • 2,800 to 6,500 foot elevation • 80 miles one way • mostly vehicular access • year-round use • easy on established roadways, difficult in non-vehicular areas. For more information call (435) 688-3200.

- **Virgin River Interpretive Trail** - Located 16 miles northeast of Littlefield • 2,240 to 2,280 foot elevation • .25 miles one way • for interpretive use only • best during spring, fall and winter • easy trail. For more information call (435) 688-3200.

- **Vulture Peak Trail** - Located eight miles south of Wickenburg • 2,400 to 3,660 foot elevation • three miles total • hiking to summit, equestrian on surrounding foothills • best during fall, winter and spring • difficult on upper stretches, moderate on lower stretches. For more information call (602) 580-5500.

- **Wabayuma Peak Trail** - Located 30 miles southeast of Kingman • 6,047 to 7,601 foot elevation • three miles one way • for hiking only • best during late spring through fall • moderate trail, some cross-country. For more information call (520) 757-3161.

Arizona BLM Trails

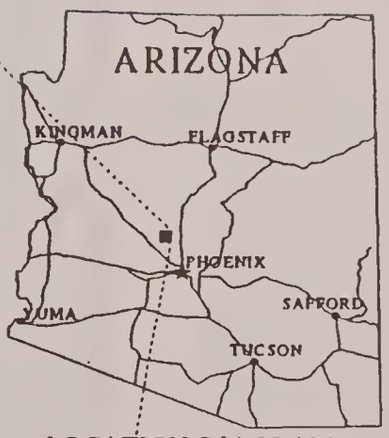


MAP 8

Map 8 is part of a handout describing BLM trails in Arizona. The map was originally produced for page-sized use, but has accommodated this approximately 50% reduction quite well. The main problem is the addition of two new trails, both in the NW quadrant of the map. Note that the symbol and text for Cherum Peak do not exactly match the other symbols and text on the map. This is a somewhat subtle distinction, but a closer match would have been advisable. The real problem is the Mohave & Milltown RR trail. This new text has been placed right *on top* of the text for the city of Kingman and the symbol for Interstate route 40. This has made all of the effected text essentially unreadable. Amazing as it may seem, this blunder was never caught and thousands of copies of the map have been distributed to the public. This certainly points out the need for active quality control in mapping.

Lessons Learned: All maps, no matter what their size or complexity, should be thoroughly reviewed and edited before copies are printed and distributed. (See Essay 7.)

Hell's Canyon Wilderness



LOCATION DIAGRAM

MAP LEGEND

- WILDERNESS AREA
- DRAINAGES
- SECONDARY ROADS AND TRAILS
- PRIMARY GRADED ROAD
- COUNTY BOUNDARY
- LAKE PLEASANT REGIONAL PARK
- SPRINGS

N

SCALE

0 1 2

MILES

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

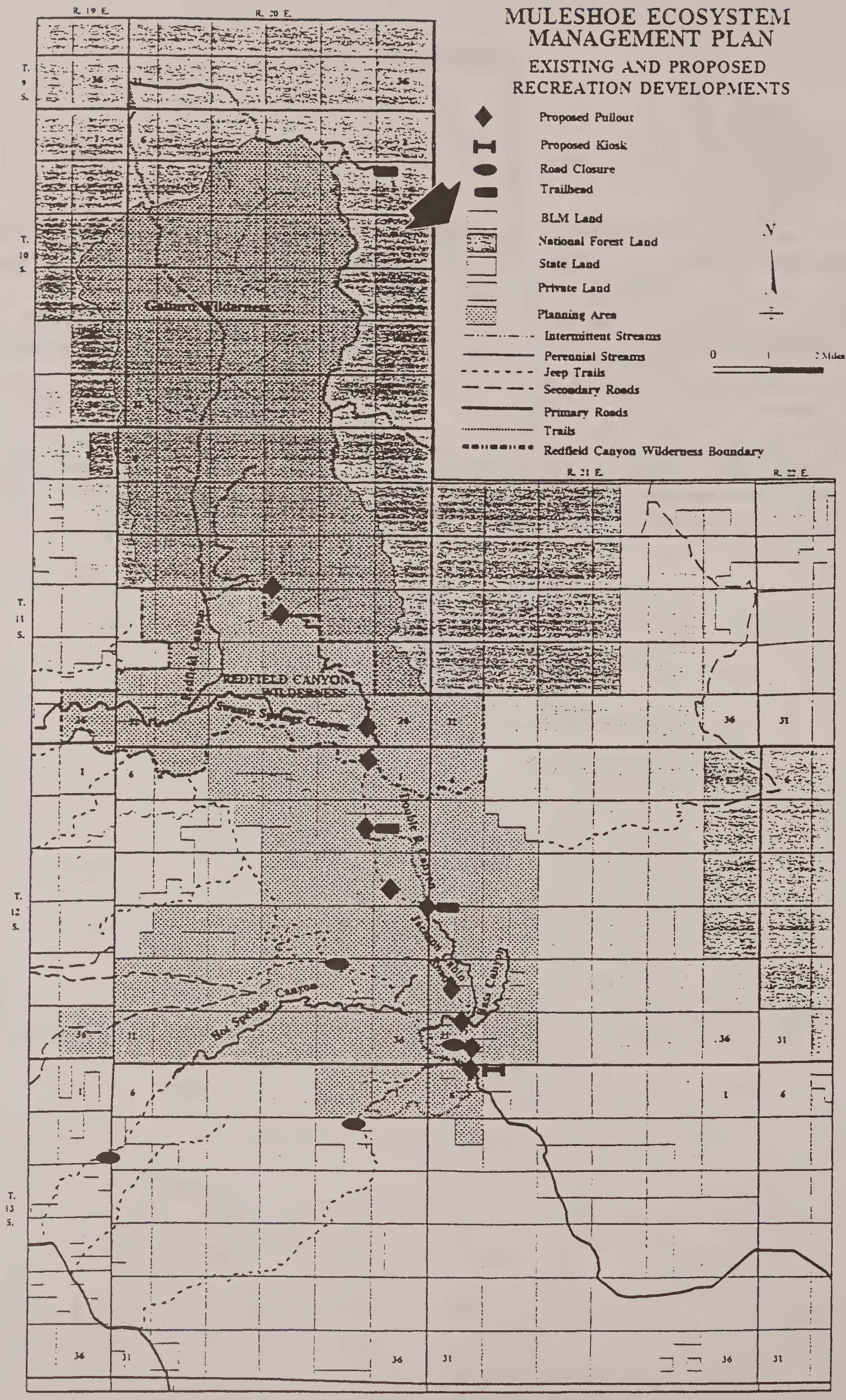
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
PHOENIX DISTRICT

Map 1: General Area

MAP 9

This map was used in a document. A general criticism is that it is fairly hard to read. There are a number of specific things wrong with it and I will mention just a few of them here. (1) Many of the line weights are of similar thickness, making differentiation of various features difficult. (2) Some of the text is hard to read. (3) The map is crooked within its neat line (this leads to a lack of confidence in its overall accuracy by the reader). (4) The wrong features are in italics. Only water features should be italicized. (5) Legend symbols should always be the *same size* as those used on the map. Note that this is not the case for the "springs" symbol. Also, the Lake Pleasant Regional Park boundary line should not be "boxed" in the legend. (6) Contour lines should be added to the legend, the contour interval should be given, and contour elevations need to be shown on the map. (As it stands now, we have no idea of what elevation or vertical relief exists in this area.) (7) The logo is too large. It should be reduced in size or eliminated, thus allowing more space for other items in the legend.

Lessons Learned: Attention to detail is always needed in the design and construction of maps.


MULESHOE ECOSYSTEM
MANAGEMENT PLAN
EXISTING AND PROPOSED
RECREATION DEVELOPMENTS
Proposed Pullout
Proposed Kiosk
Road Closure
Trailhead
BLM Land
National Forest Land
State Land
Private Land
Planning Area
Intermittent Streams
Perennial Streams
Jeep Trails
Secondary Roads
Primary Roads
Trails
Redfield Canyon Wilderness Boundary
N
0
1
2 Miles
R. 19 E.
R. 20 E.
R. 21 E.
R. 22 E.
T. 9 S.
T. 10 S.
T. 11 S.
T. 12 S.
T. 13 S.
Galiuro Wilderness
REDFIELD CANYON
WILDERNESS
Swamp Spring Canyon
Hot Springs Canyon
Jackson Cabin
Jay Canyon
36
31
1
6

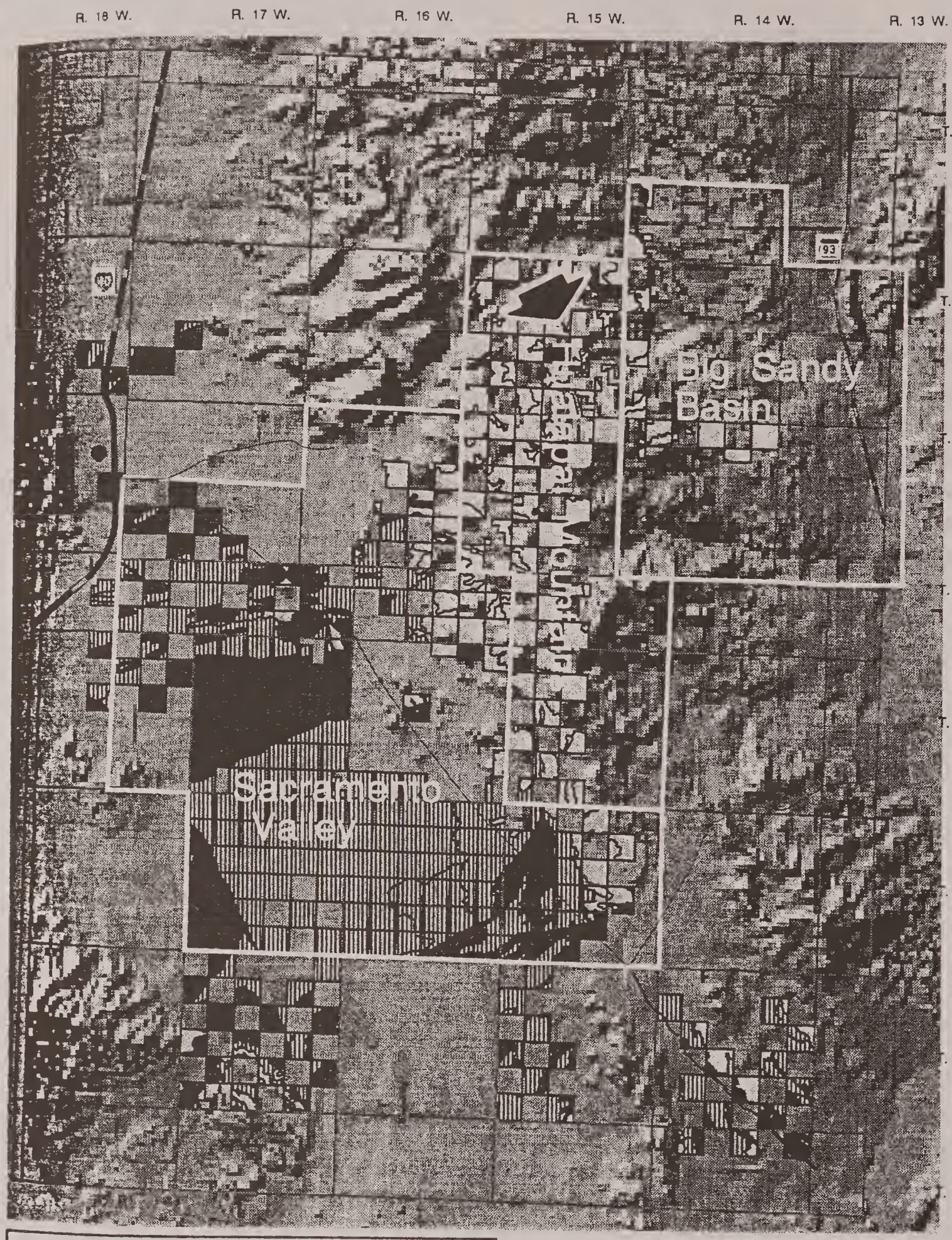
MAP 10

This map has a number of difficulties. For example, some of the trails, streams, roads, and boundaries are hard to see and (in some cases) the line weights & styles don't match well between the map and the map legend. Some of the text is also hard to read. The main problem I want to call attention to, however, is the fact that you can't distinguish the difference in the tones used on the map. The patterns for BLM Land, State Land, and Private Land all look the same, namely white or clear. This is a good example of a situation where map reduction and the printing process were not taken into account in the design of the map. The original tones used for the above mentioned land ownership were obviously too light in weight and (perhaps) similar in style to be able to survive the reduction in size and multiple generations in reproduction required to print the map. They simply "patched out" and disappeared. A variety of tones should have been tested first – reduced to publication size to see how they held up – before being used on the final map. This could have easily been done on a common, good quality, copy machine.

Lessons Learned: Final publication size and the multiple generations of the image required in the printing process need to be taken into account in map design (especially when tones are involved).

MAP 11

Map 5. Hualapai Mountain/Dutch Flat Area
Hydrologic Study Area and Erosion Potentials

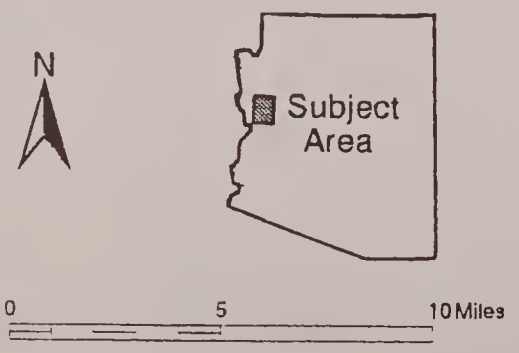


LEGEND

- Severe Erosion Potential
- Moderate Erosion Potential
- Slight Erosion Potential
- Boundaries of Hydrologic Study Area
- Major Road
- Secondary Road

Topography is from 1:250,000 digital elevation model

Hualapai Mountain Exchange

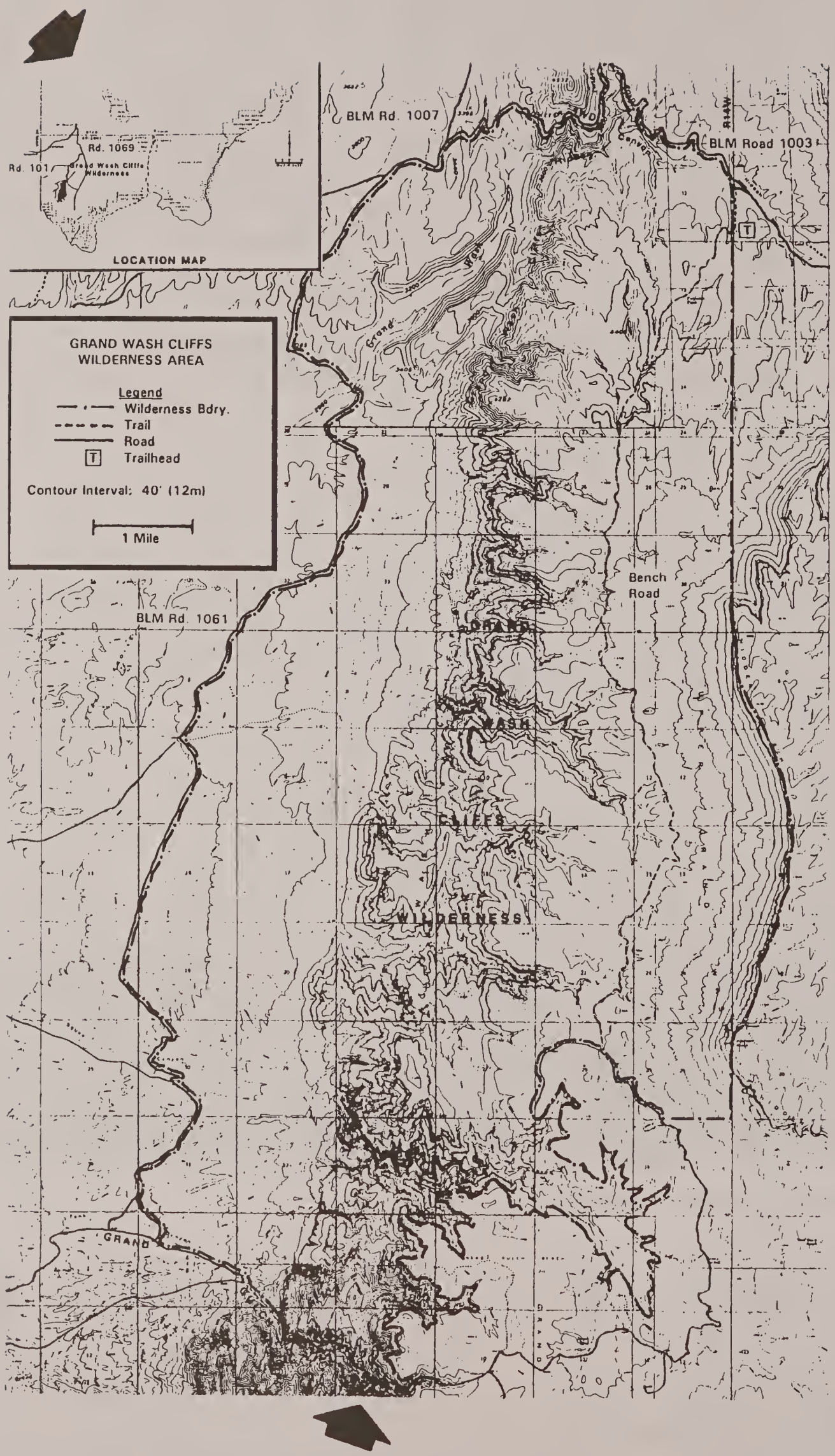


MAP 11

The ability to include shaded relief on maps today is a great advantage in showing the true topography of the land. However, care must be taken to make sure that it is used effectively. In this example the shaded relief base has been enlarged too much; the individual pixels are very apparent, making for a poor quality map. In addition, because of the complexity of the base, the white text and lines are hard to read. Also, we are not even sure where the " Severe Erosion Potential" area actually lies on the map. (Probably the tones in the legend – and on the map – should have been reversed. "Severe Erosion Potential" should have been dark, while "Slight Erosion Potential" should have been light.) This map would have been more effective – and especially more readable – if it had been done as a line drawing with only an outline indicating the mountainous regions.

Lessons Learned: Shaded relief is an excellent addition to portray terrain on a map, but it adds complexity to the design and must be used wisely to maintain the readability of the map. (See Essay 4.)

MAP 12

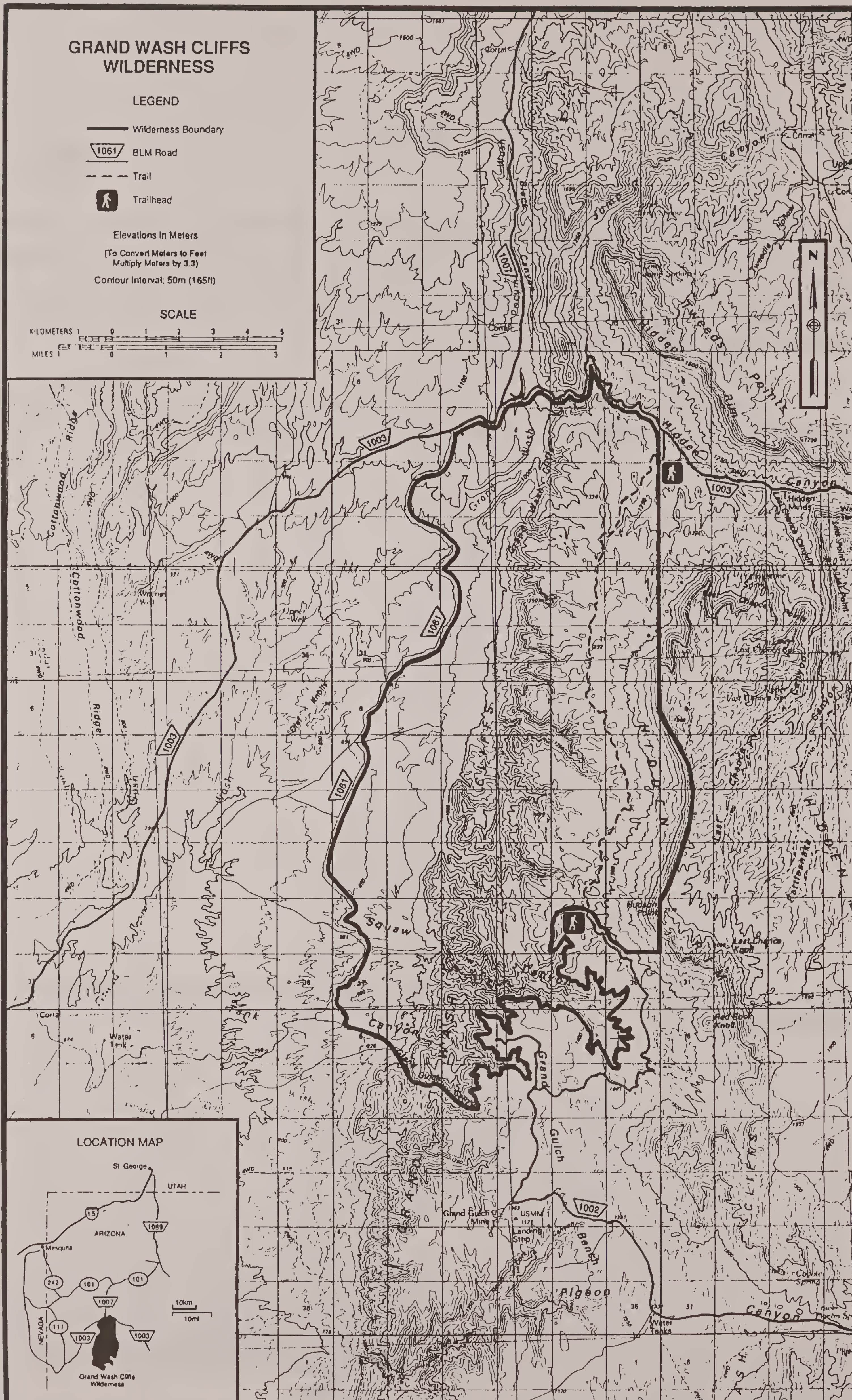

LOCATION MAP
Rd. 1069
Rd. 101
Grand Wash Cliffs Wilderness
BLM Rd. 1007
BLM Road 1003
GRAND WASH CLIFFS
WILDERNESS AREA
Legend
Wilderness Bdry.
Trail
Road
Trailhead
Contour Interval: 40' (12m)
1 Mile
BLM Rd. 1061
Bench
Road
GRAND
WILDERNESS
CLIFFS

MAP 12

This is a reduction to 60% of original size, of a map that was to be used in a document at the 11" x 17" size. Even in its larger publication format, it was of very poor quality. The contour lines run together into a "mass," contour numbers are too small to be seen, most of the map text is too small, the location map is so tiny that it is unreadable, the trailhead symbols are hard to see, and even the wilderness boundary line is difficult to follow.

This is an excellent example of the use of a map base that has been reduced to a size that is too small for publication. See Map 12A for a redesign of the map by the author.

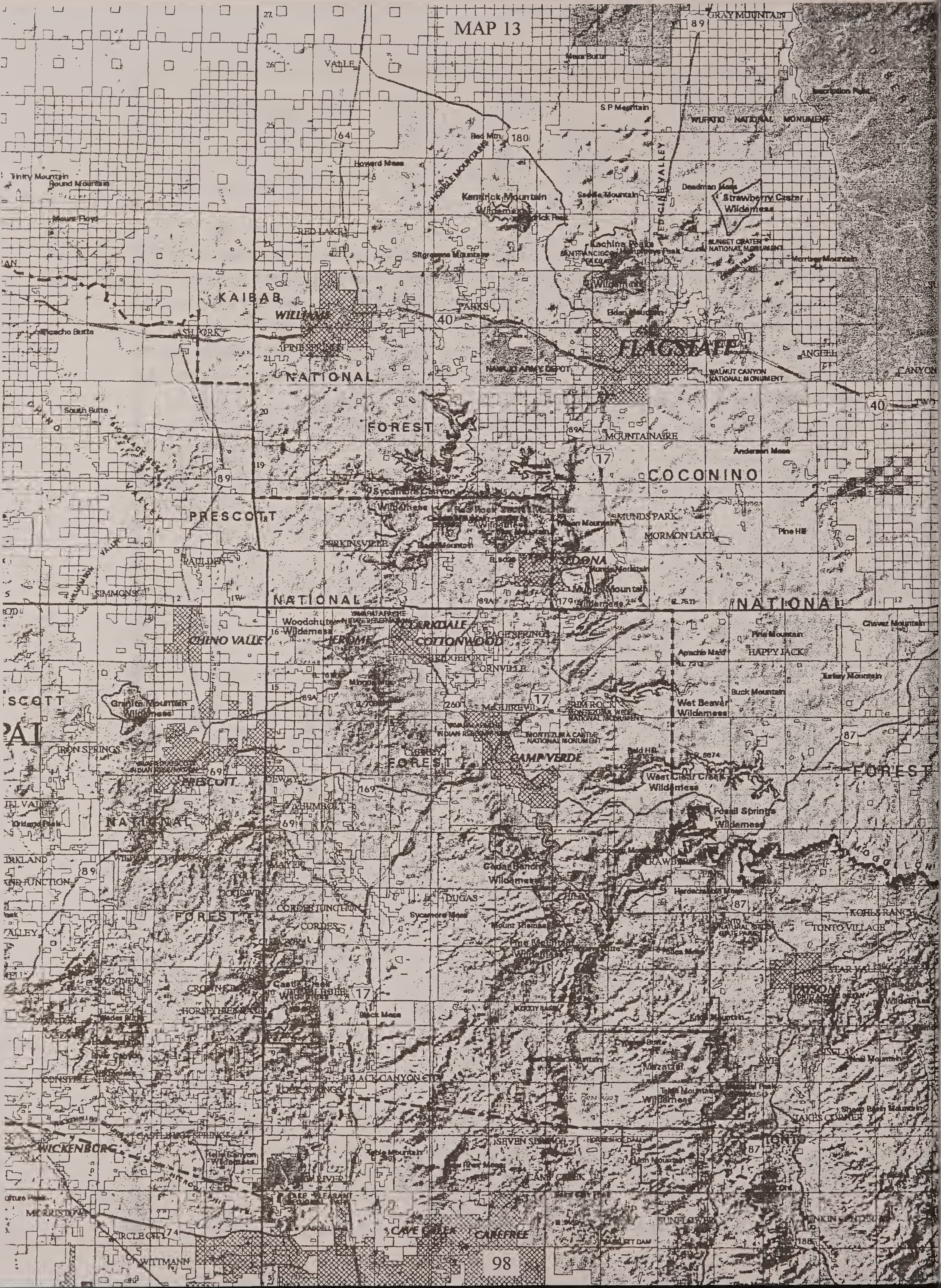
Lessons Learned: Reducing a map base much smaller than its original design size results in an unreadable map.


GRAND WASH CLIFFS
WILDERNESS
LEGEND
Wilderness Boundary
1061 BLM Road
Trail
Trailhead
Elevations In Meters
(To Convert Meters to Feet Multiply Meters by 3.3)
Contour Interval: 50m (165ft)
SCALE
KILOMETERS 1 0 1 2 3 4 5
MILES 1 0 1 2 3
LOCATION MAP
St George
UTAH
ARIZONA
Mesquite
NEVADA
Grand Wash Cliffs Wilderness
Cottonwood Ridge
Squaw Canyon
Grand Gulch
Pigeon Canyon
Hidden Canyon
Hudson Point
Last Chance Knoll
Red Rock Knoll
Grand Gulch Mine
Landing Strip
Water Tanks
Water Tank
Corral
Hidden Mines

MAP 12A

Map 12A is a redesign of Map 12. This is a reduction to 60% of the actual 11" x 17" publication size, so it still looks small (and was not meant to be used at page size). But, compare it with the previous map (also shown at 60% size)! A different map base was used and lines, text, and symbols were enlarged. The contour lines are all now separately visible and the contour numbers are readable (at the 11" x 17" size). Likewise the map text and location map are readable, and the boundary line and trailheads are very apparent. The features of the map are now visible and, consequently, the map is readable and useable.

Lessons Learned: A map base used at a reasonable size results in a readable map.


GRAY MOUNTAIN
VALLE
S P Mountain
WUPATKI NATIONAL MONUMENT
Red Mtn.
Howard Mesa
Trinity Mountain
Round Mountain
Kendrick Mountain Wilderness
Saddle Mountain
Strawberry Crater Wilderness
Mount Floyd
RED LAKE
Sitgreaves Mountain
Kachina Peaks
SUNSET CRATER NATIONAL MONUMENT
Marshall Mountain
KAIBAB
WILLIAMS
PARKS
ASH FORK
Picacho Butte
PINE SPRINGS
FLAGSTAFF
NAVAJO ARMY DEPOT
WALNUT CANYON NATIONAL MONUMENT
NATIONAL
ANGELL
CANYON
South Butte
FOREST
MOUNTAINAIRE
Anderson Mesa
COCONINO
Sycamore Canyon Wilderness
PRESCOTT
MUNDS PARK
MORMON LAKE
Pine Hill
PERKINSVILLE
SEDONA
Munds Mountain Wilderness
PAULDEN
SIMMONS
NATIONAL
NATIONAL
Chavez Mountain
Woodchute Wilderness
JEROME
CLARKDALE
COTTONWOOD
PAGE SPRINGS
Pine Mountain
HAPPY JACK
CHINO VALLEY
BRIDGEPORT
CORNVILLE
Turkey Mountain
Buck Mountain
Granite Mountain Wilderness
McGUIREVILLE
RIMROCK
Wet Beaver Wilderness
IRON SPRINGS
MONTEZUMA CASTLE NATIONAL MONUMENT
FOREST
CAMP VERDE
West Clear Creek Wilderness
FOREST
PRESCOTT
DEWEY
HUMBOLDT
NATIONAL
Fossil Springs Wilderness
KIRKLAND
KIRKLAND JUNCTION
MAYER
Cedar Bench Wilderness
STRAWBERRY
PINE
DUGAS
FOREST
CORDES JUNCTION
CORDES
Sycamore Mesa
KOHLS RANCH
TONTO VILLAGE
Pine Mountain Wilderness
STAR VALLEY
PAYSON
Castle Creek Wilderness
Black Mesa
CONSTELLATION
BLACK CANYON CITY
Mazatzal Wilderness
RYE
WICKENBURG
CASTLE HOT SPRINGS
Hells Canyon Wilderness
SEVEN SPRINGS
Table Mountain
JAKES CORNER
TONTO
MORRISTOWN
LAKE PLEASANT
CAVE CREEK
CAREFREE
SUNFLOWER
BARTLETT DAM
CIRCLE CITY
WITTMANN

MAP 13

A small part of an Arizona state map is shown here at its proposed publication size 1:800,000. The original is in color, which helps the visibility to some degree (but not much). A few of the problems include: text that is hard or impossible to read, incorrectly italicized text, overlapping text, incorrectly sized text, overlapping symbols, off-centered symbols, missing symbols, symbols used on the map but not defined in the legend, boundary lines that are hard or impossible to follow, missing roads and road numbers, and poorly placed text and numbers. There are also contrast problems throughout.

This is a good example of a map that suffers from an attempt to place too much information upon it. It is also an example of computer layering problems, wherein different map layers are combined with resulting text and symbol overlap. If the map is to be printed at this scale, it needs to be simplified, have the text and symbols that remain made larger, and be edited to make sure the various layers do not incorrectly overlap. (See also Appendix III.)

Lessons Learned: Do not try to show so much information on a map – at so small a scale – that it becomes unreadable. Be sure that various map layers from a computer do not result in overlapping text, symbols, and other information.


Quartzsite
Julian Mine
Granite Mtn
Cholla Road
OLD YUMA RD
LA PAZ VALLEY RD
PIPELINE
Wash
Kellogg
Yum Yum Mine
Eightmile Well
297
277
300
302
L A P O S A
4WD

MAP 14

This is a small part of a colored off-highway vehicle guide map. It is shown here at its printed scale of 1:62,500. The dashed lines indicate 4WD trails and they are all numbered, this being the main purpose of the map. The obvious problem is the complexity. It is very difficult, in many cases, to discern which number goes with which trail (and in fact, where some of the trails actually go). This is another example of too much information in too small a space.

There are several possible solutions to this problem. One is to enlarge the overly complex areas and place these enlargements off to the side, where space is available. If there is no room on the front, the enlargements could be printed on the reverse side of the main map (with perhaps additional information added). Another solution is to design the entire map at a larger scale and divide it into two – or more – individual maps that together cover the same territory. A third solution would be to eliminate some of the trails and only show the "most important" ones (this may or may not be feasible). In any event, the goal remains the same: to make the map more readable.

Lessons Learned: Maps with more information on them than their scales will allow must be redesigned so they will be more easily readable. (This map in particular suffered from planning problems: see Essay 6.)

MAP 15

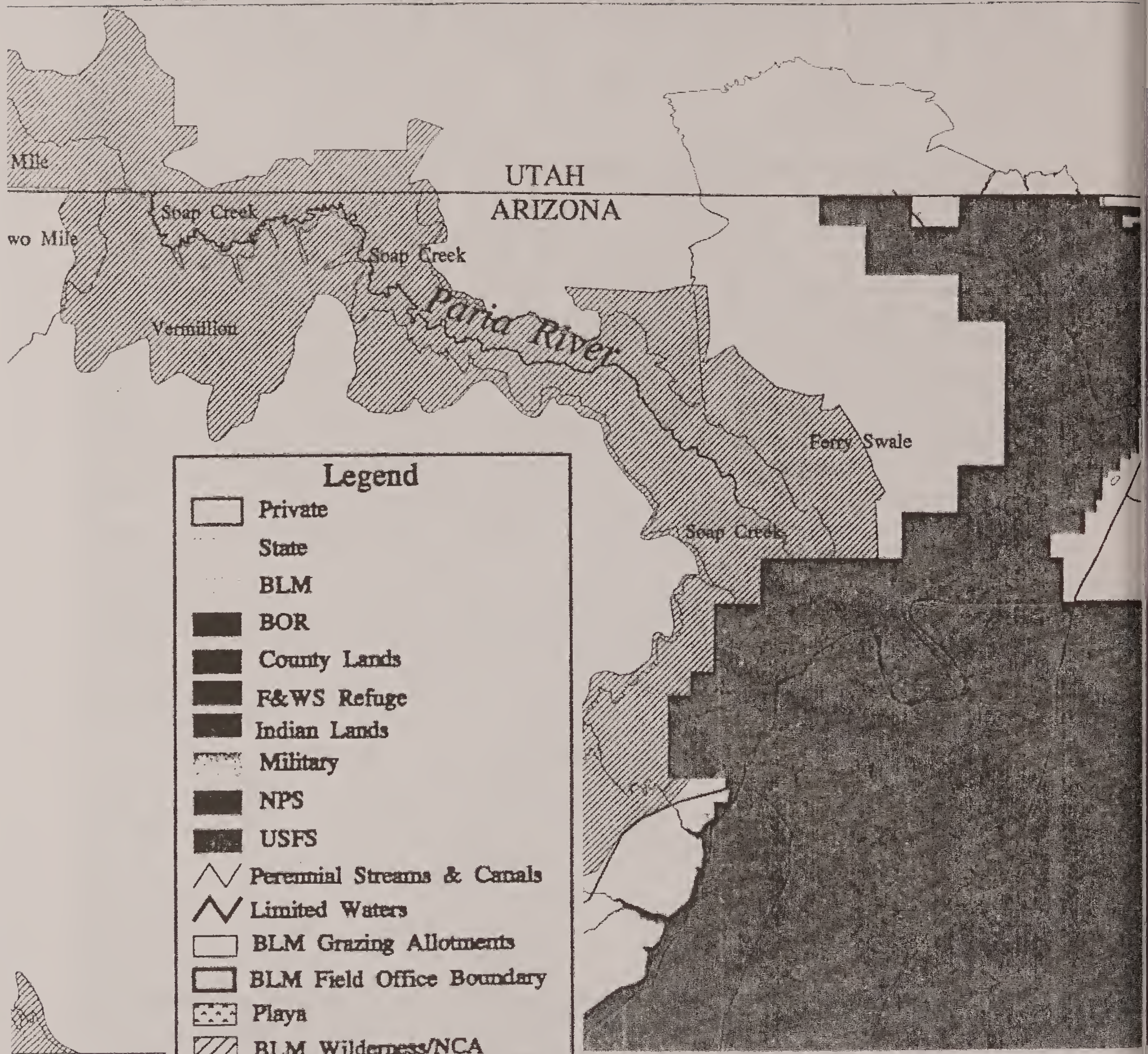
MAP 15

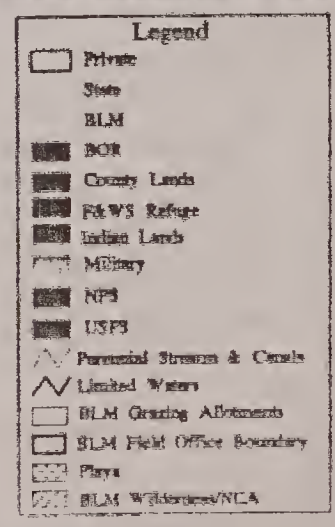
Map 15 was produced to be mounted on a board for display at a public meeting. It was originally in color and approximately 36" x 52" in measurement. Obviously it has suffered greatly from being reduced to page-size here (approximately a reduction to 20% of original dimension). However, even at this small size, a number of design problems and omissions are apparent. (1) There is no title. How are we to know what this map is about? (2) There is no location map. How are we to know (easily) where this map is located within the state? (3) There *is* a scale bar and a north arrow, although the 1:28000 proportion is not really needed. (4) There is no legend. The original map is color coded by land management agency but without a legend indicating what color corresponds to what manager, this color scheme is worthless. (5) The area of interest (the whole purpose of the map) is very poorly indicated by either line or large text. One has to look all over the map to find this information (in this case it's an archaeological area). (6) Likewise, nearby features which could be used to orient the reader (there are a major freeway and two towns located on the map) are not prominent in their labels at all. (7) Practically all of the text on this map is very small – not at all what is required for a display (see Appendix III).

This map should have been treated as a "display graphic" in order to make it successful. See Appendices I and II for a discussion of some of the factors that need to be considered for this type of a presentation.

Lessons Learned: A map used for exhibit and/or display needs to have its subject and supporting matter prominently displayed, so that the viewer can comprehend the desired information in a very brief period of time. All this material must be of such a size that it can be seen and read from an adequate distance (ideally, several feet away).

PARIA RIVER LIMITED WATERS & GRAZING ALLOTMENTS





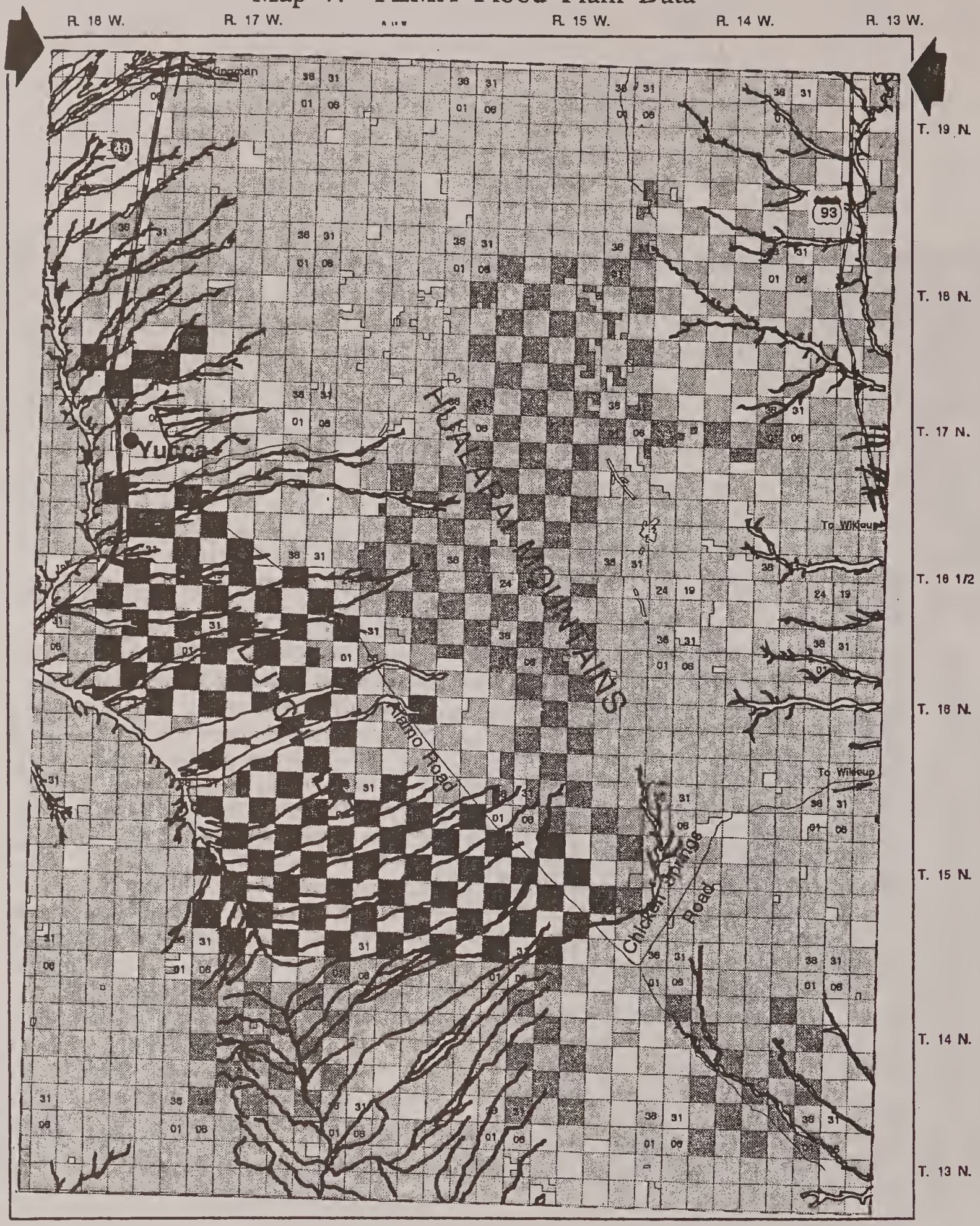
MAP 16

Map 16 is part of a colored chart originally approximately two feet square in size and shown reduced here. The main reason for discussing this map is the legend, which has been enlarged for visibility and placed over the left center part of the page. As you can see, the legend has 16 different items listed. Unfortunately, 6 of the items are not displayed on the map itself. The boxes labeled BOR, County Lands, F&WS Refuge, Military, USFS, and Playa should have been excluded from the legend. (Admittedly, this can't be well seen in this black & white reproduction. It is, however, such an important point that I wanted to discuss it here.) Apparently the legend was transferred to the map as a complete computer layer, without checking which items were actually present. This points up the need for vigilance when working with layering; the information in the legend and on the map must match.

A few other comments might be mentioned. (1) The "Perennial Streams & Canals" and the "Limited Waters" designations in the legend should be *straight lines*. The zigzag lines currently shown indicate that the lines are of zigzag form on the map, which is certainly not true. (2) Concerning proportions, the north arrow is too large and the bar scale is much too small. (3) The large logo should be replaced with a location map, which would be much more informative. (A *smaller* logo could be placed somewhere else on the map, if it is deemed necessary.)

Lessons Learned: All the items included in a map legend must also appear on the map. And the converse is also true: symbols, patterns, colors, etc. that are shown on the map should also be displayed and explained in the legend.

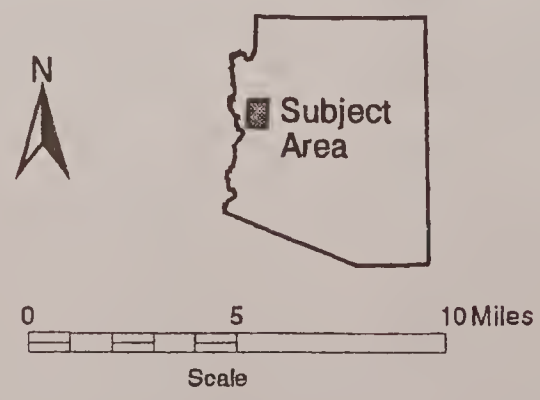
Map 7. FEMA Flood Plain Data



LEGEND

- Q3 Flood Data SFHA zone
- Offered/Private Land
- Selected/Public Land
- Public Land
- State Land
- Private Land
- Penstemon ACEC Boundary
- Wilderness
- Major Road
- Secondary Road

Hualapai Mountain Exchange



MAP 17

This map creates a number of questions in the mind of the reader. (1) Is the "Q3 Flood Data SFHA Zone" just the *open* dendritic pattern, or does it include the *solid* dendritic lines too? The legend should show this. (2) Where is the "Penstemon ACEC Boundary?" (3) At least three of the grey shades used on the map are too similar in density. You can't tell them apart. (4) The map is really crooked within its neat line. This is unacceptable. It certainly puts doubt about the map quality in the reader's mind. *If they can't even get the map straight on the page, what can I expect about the accuracy of the information on the map itself?!*

Lessons Learned: Care is needed in making sure the information on a map is understandable. The map should also certainly be straight on the page.

MAP 18

This is an example of a poor quality computer scanned and generated map. The contour lines are broken or have bled together in many places. Also the text and contour numbers are, for the most part, unreadable. Unfortunately, many map bases wind up looking similar to this. Proper care and adequate equipment must both be used in order to achieve a successful map.

Lessons Learned: No matter what method of map construction is used – traditional pen & ink or modern computer – the map base must be readable or the map is a failure.

Shaded Relief Map of Colorado

Data Sources
Relief: USGS 3 Arc-second DEMs
Highways: Colorado DOT
Towns & Cities: DCW
F.O. Boundaries: BLM

Map Legend

- Cities
- Towns
- Interstate Highways
- Other State Highways
- Field Office Boundaries

- Above 12,000
- 11,500' - 12,000'
- 11,000' - 11,500'
- 10,500' - 11,000'
- 10,000' - 10,500'
- 9,500' - 10,000'
- 9,000' - 9,500'
- 8,500' - 9,000'
- 8,000' - 8,500'
- 7,500' - 8,000'
- 7,000' - 7,500'
- 6,500' - 7,000'
- 6,000' - 6,500'
- 5,500' - 6,000'
- 5,000' - 5,500'
- 4,500' - 5,000'
- 4,000' - 4,500'
- 3,500' - 4,000'
- 3,000' - 3,500'

Colorado State Office
Resource Services

January, 1998

N
W E
S

10 0 10 20 30 40 50 Miles

MAP 19

Map 19 was originally displayed as a color poster in the 3 ft. x 4 ft. size range. It suffers by being greatly reduced and then reproduced in black & white as shown here. However, I want to call the reader's attention to the extensive number of elevation range colors shown in the legend (a different color for every 500 ft.). On the original large map these are shown primarily as a series of tan shadings. The problem is that there are so many shadings, so close together in tone, that they can't be differentiated on the map. There is no way to tell, for example, exactly where the 10,000 – 10,500 ft. areas are located. Thus, this map gives a false sense of accuracy. You can't determine precisely where the various elevation ranges lie.

There are a couple of ways to remedy this situation. One would be to restrict the elevation ranges to approximately half a dozen divisions, so only half a dozen tones would be required – and therefore could be easily differentiated. Another way would be to use a "one box" gradual tone procedure. In this approach the tones would gradually merge with one another and only *general* elevations (3000 ft., 6000 ft., etc.) would be indicated. This method would show the elevation range, but not attempt to commit to exact (and impossible to find) altitudes.

Lessons Learned: The number of shading divisions in a map legend (whether in color or black & white) should be easily discernible on the map itself. It the reader can't understand the transition between legend and map, the legend should be modified.

Field Office Boundary
6 Mile Buffer of F.O.
Township/Range Lines
BLM Lands

Gapveg

Agriculture
Chihuahuan Creosotebush-Tarbush Scrub
Chihuahuan Mesquite Shrub Hummock
Chihuahuan Mixed Scrub
Chihuahuan Whitethorn Scrub
Douglas Fir-Mixed Conifer
Encinal Mixed Oak
Encinal Mixed Oak-Mesquite
Encinal Mixed Oak-Mexican Mixed Pine
Encinal Mixed Oak-Pinyon-Juniper
Encinal Mixed Oak/Mixed Chapparal/Semidesert Grassland-Mixed Scrub
Industrial
Int. Chaparral (Mixed)/Son. Paloverde-Mixed Cacti
Int. Chaparral-Mixed Evergreen Sclerophyll
Int. Chapparal (Mixed)/Mixed Grass-Scrub Complex
Int. Chapparal-Shrub Live Oak-Pointleaf Manzanita
Int. Riparian/Cottonwood-Willow Forest
Int. Riparian/Mesquite Forest
Int. Riparian/Mixed Broadleaf Forest
Int. Riparian/Mixed Riparian Scrub
Mixed
PJ (Mixed)/Mixed Chapparal-Scrub
PJ-Shrub/Ponderosa Pine-Gambel Oak-Juniper
Pinyon-Juniper-Mixed Grass-Scrub
Playa
Ponderosa Pine
Ponderosa Pine-Mixed Conifer
Semidesert Mixed Grass-Mesquite
Semidesert Mixed Grass-Mixed Scrub
Semidesert Mixed Grass-Yucca-Agave
Semidesert Tobosa Grass-Scrub
Son. Riparian/Cottonwood-Mesquite Forest
Son. Riparian/Cottonwood-Willow Forest
Son. Riparian/Leguminous Short-Tree Forest/Scrub
Son. Riparian/Low-lying Riparian Scrub
Son. Riparian/Mesquite Forest
Son. Riparian/Mixed Broadleaf Forest
Son. Riparian/Mixed Riparian Scrub
Son. Riparian/Sacaton Grass Scrub
Son./Chih. Riparian/Reed-Cattail Marsh
Sonoran Creosotebush Scrub
Sonoran Creosotebush-Bursage Scrub
Sonoran Creosotebush-Bursage-Paloverde-Mixed Cacti (wash)
Sonoran Creosotebush-Mesquite Scrub
Sonoran Paloverde Mixed Cacti/Sonoran Creosote-Bursage
Sonoran Paloverde-Mixed Cacti-Mixed Scrub
Sonoran Paloverde-Mixed Cacti/Semidesert Grassland-Mixed Scrub
Sonoran Saltbush-Creosote Bursage Scrub
Urban
Water

MAP 20

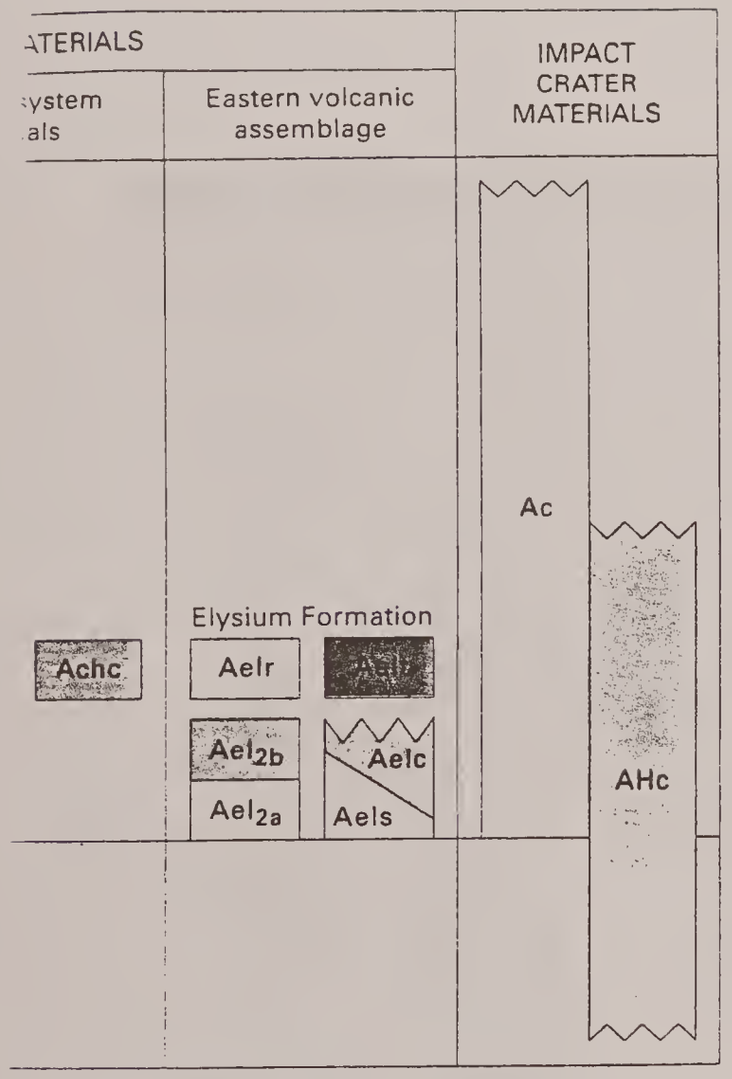
Actually, the map in this example has been omitted. It is in color and *very complex*, so does not reproduce well in black & white. What *is* shown, is the lengthy legend that accompanies the map, and that is what I want to discuss. Obviously, you cannot distinguish many of the similar tones in this black & white reproduction. The problem is that, even in color (on the original map), many of the color shadings are also too similar to tell apart. How can we handle this kind of a situation?

One way to get around this problem – especially if the map is to be produced at a smaller scale – is simplification. If some of the items (and thus colors) can be combined, you will be able to differentiate the fewer remaining ones.

Another way to solve the problem is to use all the needed colors, but to number or letter them as well (one number or letter for each color used). In this way, even if some of the color tones are similar, the numbers or letters will tell you exactly what item in the legend they are referenced to. This system has been used very successfully in geologic mapping for many years. (For a sample, see Map 20A.)

Lessons Learned: When possible, maps that are overly complex with regard to the number of items (and thus colors) shown should be simplified. If this is not feasible, a color numbering or lettering system often may be used to display the desired information.

OF MAP UNITS



OF MAP UNITS

RAIN MATERIALS

ns assemblage

aced, subparallel ridges and rows of mounds less than level terrain at base of slopes in grooved plains mate- mass wasting of water-ice-rich materials

ireless plains-forming materials; lightly cratered. Occurs graphic basins throughout map area. *Interpretation*: ls, including mass wasting, fluvial, and eolian deposits, lution

ooth deposits marked by numerous rounded knobs; grooved plains and smooth plains in Elysium and Uto- s formed by degradation of ice-rich high plains materi-

Apg — **Grooved plains material**—Occurs north and west of Elysium rise, adjacent to lava flows of Elysium Mons. Polygonal-shaped mesas that form blocky-appearing mesas separated by flat-floored troughs 1–2 km wide. Surface expression varies from sharp-edged polygons in adjacent quadrangle to subdued, rounded polygons at western and northern occurrences. *Interpretation*: Distal Elysium lava flows broken by flowage of subsurface material; probably related to ground-ice melting induced by volcanism

Aph — **Hilly plains material**—Relatively smooth deposits having closely spaced small knobs less than 1 km basal diameter. Occurs on and adjacent to grooved plains material. *Interpretation*: Formed by advanced degradation of ice-rich grooved plains material

Apf — **Fluted plains material**—Smooth, level plains having low-relief fluting. Intersecting pattern of linear hollows. Occurs adjacent to the head of Hrad Vallis. *Interpretation*: Dune fields or mudflow (lahar) originating from source of Hrad Vallis and Galaxias Fossae

Channel-system materials

Channel material—Deposits within channels that originate from troughs and fractures along northwest base of Elysium rise and that extend northwesterly into Utopia Planitia. Channels cut coarse and smooth members of Elysium Formation. *Interpretation*: Colluvium derived from valley walls and fluvial material deposited by water discharged through volcanic fissures

Achp — **Flood-plain material**—Occurs as smooth plains of terraces adjacent to channels, in topographic narrows connecting topographic basins, and in topographic basins connected by channels. Locally preserved as streamlined islands within channels. *Interpretation*: Alluvial and lacustrine plains formed by deposition in low-lying troughs and basins or overbank deposition of reworked sediments

Achc — **Chaotic channel material**—Ranges from slightly displaced valley walls to jumbled wedge-shaped blocks and highly chaotic materials along valley walls and flood plains. *Interpretation*: Slump blocks and terrain collapsed by slope failure; possibly thixotropic clay flowage

Eastern volcanic assemblage

Elysium Formation—Volcanic and related materials associated with Elysium Mons shield; members largely modified from those defined by Greeley and Guest (1987) and Tanaka and others (1992)

Aelr — **Rugged ridge material**—Forms elongate to linear, rugged topographic highs with scalloped flanks. Crests trend parallel to regional fissure and fault trend. *Interpretation*: Erosional remnant of high-standing material; viscous volcanic materials extruded along fractures or doming due to injection of subsurface water or ice along fracture zone

Trough member—Slope, wall, and floor material of Galaxias Fossae. *Interpretation*: Debris apron formed by mass wasting of walls of fissure and sedimentary material moved by fluvial processes along floor of fissures

Ael_{2b} — **Member 2b**—Widespread, fresh-appearing, lobate flows that cover most of Elysium rise; flows originate from Elysium Mons and surrounding fissures and embay older flows of Hecates and Albor Tholi and ridged plains material elsewhere around Elysium Mons. Moderately fractured, pitted, and cratered. Superposed impact crater blankets commonly have radial or fluidized texture. *Interpretation*: Lava flows of the latest volcanic activity in the area

Ael_{2a} — **Member 2a**—Plains-forming material around Elysium Mons. Surface is smooth to gently rolling with degraded lobate scarps. Generally more cratered and pitted than member 2b. *Interpretation*: Lava flows of earlier volcanic activity associated with Elysium Mons

MAP 20A

As described in Map 20, this is an example of one of the ways to deal with the problem of a lengthy legend – one that has so many color designations that they are hard to distinguish. This sample, from a small area of a U.S. Geological Survey map, shows how this may be accomplished. The series of legend boxes each contain a different color (some of them quite similar in tone) and also a letter code designation. The reader is able to differentiate among the various units on the map, first generally by the color and then specifically by the associated letter code. If drafted properly, this method is very effective in displaying numerous map divisions and has been used on geologic maps for a long time.

Lessons Learned: A letter/number coding system works very well for distinguishing complex areas on a map.

Eagletails Mtns., Hummingbird Springs, North Maricopa Mtns., and Signal Mtn. Wilderness Areas

State of Arizona
Surface Management Responsibility - Custom 1:130,000 Scale

Hummingbird Springs Wilderness Area

Eagletail Mountains Wilderness Area

Signal Mountain Wilderness Area

North Maricopa Mountains Wilderness Area

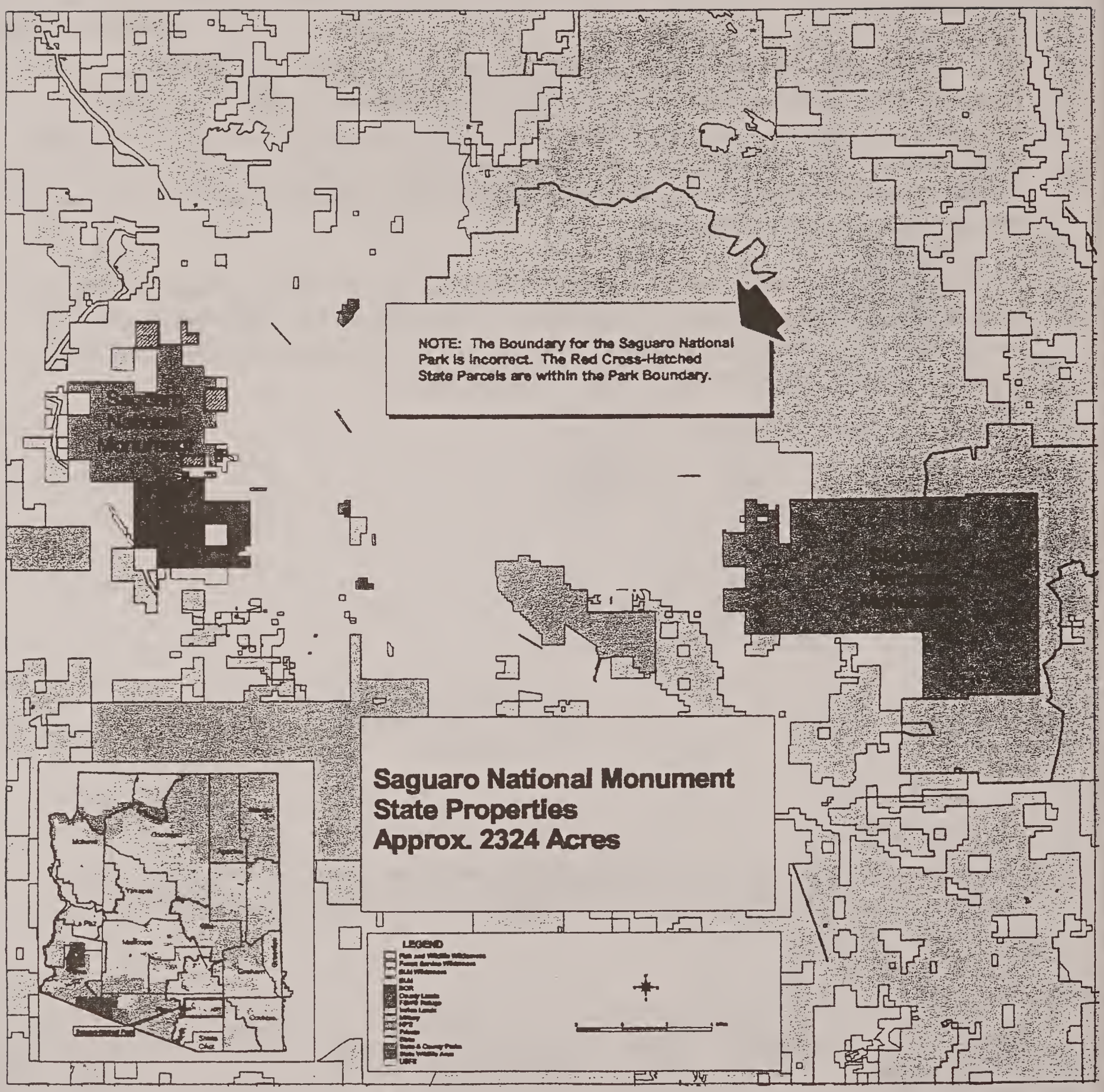
Wilderness Area	State Properties (Surface)	State Properties (Subsurface)
Eagletail Mtns.	2,720 acres	1400 acres
Hummingbird Springs	1,280 acres	0 acres
North Maricopa Mtns.	0 acres	2,080 acres
Signal Mtn.	0 acres	990 acres

MAP 21

This is another excellent example of a map that has been reduced way beyond its design capabilities. The original map was in color and was probably meant to be used in the 2 ft. x 2 ft. or 3 ft. x 3 ft. size range. For handout purposes it was reduced to page-size, as seen here. The problem is that you can't read – or hardly even see – the various items in the legend at the bottom of the map. If you can't read the information that explains the map, interpreting what the map is supposed to tell you becomes very difficult, to say the least.

In addition, the stated "custom scale" (upper right corner) of 1:130,000 is incorrect. This was the pre-reduction scale and should have been changed for the reduced map size (which is now probably more like 1:500,000 or 1:600,000). This is another factor that must be considered when applying map reductions. (See "Scale," under "Map Elements.")

Lessons Learned: Reducing a map beyond its design capabilities results in an unreadable – and therefore not understandable – map. Page-sized maps should be specifically designed for their small scale.


NOTE: The Boundary for the Saguaro National Park is incorrect. The Red Cross-Hatched State Parcels are within the Park Boundary.
Saguaro National Monument
State Properties
Approx. 2324 Acres
LEGEND

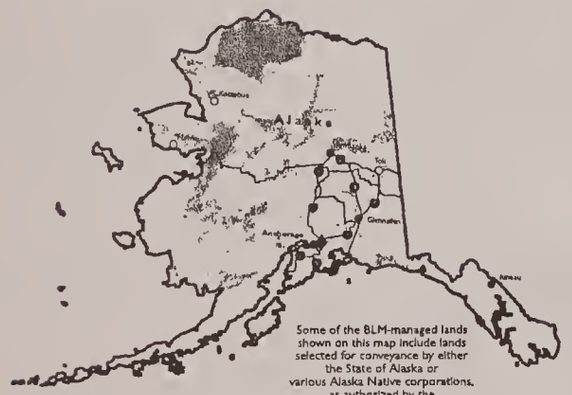
MAP 22

Like Map 21 this is another good example of a large color map that has been reduced beyond its legibility capacity in order to make it page-size. Notice how the legend, scale, north arrow, and location diagram are unreadable. This map should be redesigned to a page-sized format.

In addition, in the center of the map there is a "NOTE" stating: "The Boundary for the Saguaro National Park is incorrect. The Red Cross-Hatched State Parcels are within the Park Boundary." Since there was time available to add this note, there should have been enough time to make this relatively minor cartographic change. Maps produced for public consumption should be accurate, without the addition of correction notes or disclaimers of this type.

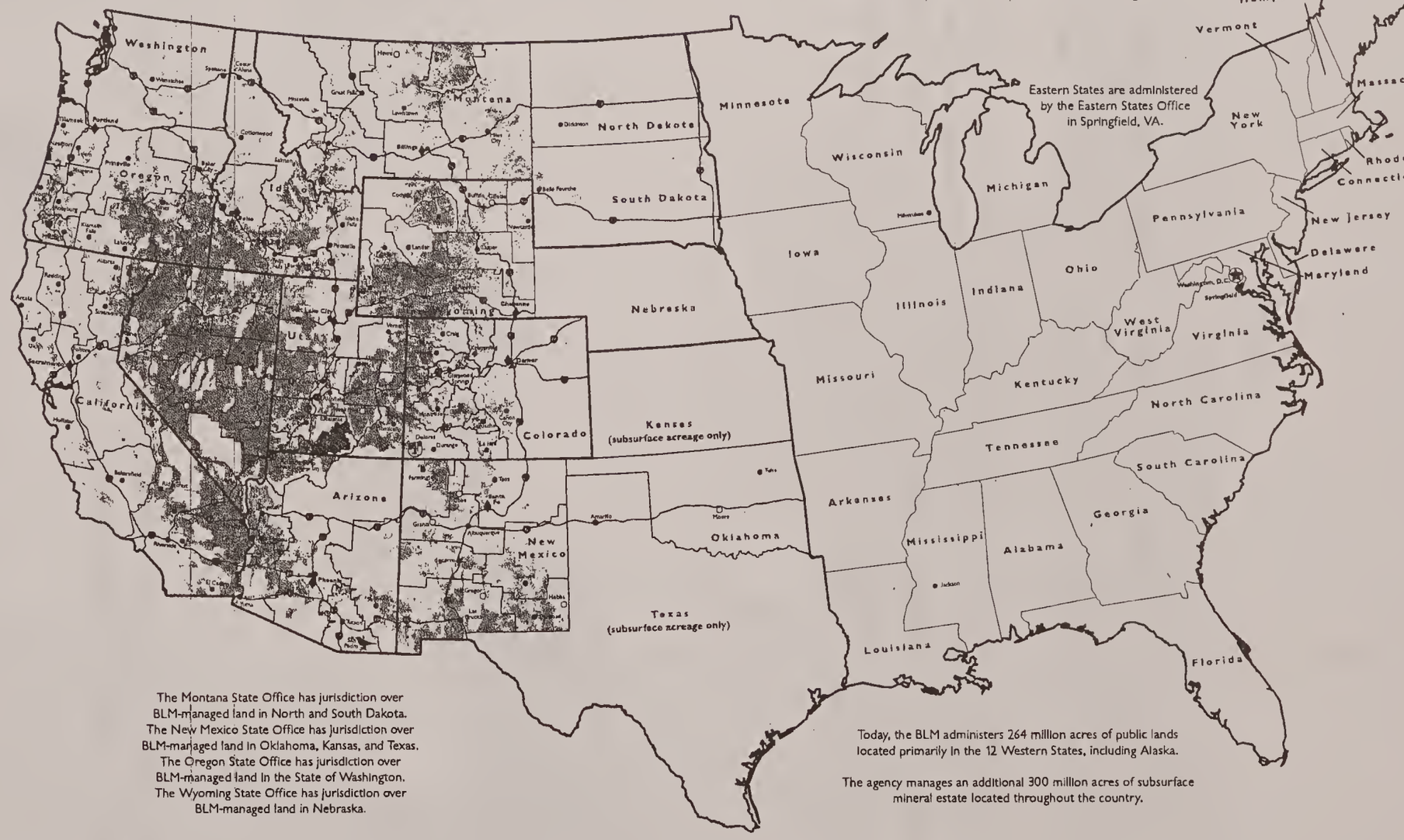
Lessons Learned: Map text and symbols must be of a readable size. Map data should be correct, without the addition of explanatory notes.

Public Lands Managed by the Bureau of Land Management (BLM)



Some of the BLM-managed lands shown on this map include lands selected for conveyance by either the State of Alaska or various Alaska Native corporations, as authorized by the Alaska Native Claims Settlement Act and other legislation.

- BLM-Managed Lands
- BLM Headquarters
- BLM State Office Locations
- BLM Field Office Locations
- BLM Field Station Locations
- BLM National Training Center
- BLM National Centers
- Yaquina Head Outstanding Natural Area Interpretive Center
- National Interagency Fire Center
- National Historic Oregon Trail Interpretive Center
- Anasazi Heritage Center
- San Pedro Riparian National Conservation Area Project Office
- BLM State Office Jurisdictions
- BLM Field Office Boundaries
- State Boundaries
- Major Highways
- Grand Staircase-Escalante National Monument



In the Eastern United States, the BLM manages 39.7 million acres of subsurface mineral estate and 30,000 acres of surface, mostly small isolated parcels scattered throughout 31 States.

Eastern States are administered by the Eastern States Office in Springfield, VA.

The Montana State Office has jurisdiction over BLM-managed land in North and South Dakota.
The New Mexico State Office has jurisdiction over BLM-managed land in Oklahoma, Kansas, and Texas.
The Oregon State Office has jurisdiction over BLM-managed land in the State of Washington.
The Wyoming State Office has jurisdiction over BLM-managed land in Nebraska.

Today, the BLM administers 264 million acres of public lands located primarily in the 12 Western States, including Alaska.

The agency manages an additional 300 million acres of subsurface mineral estate located throughout the country.

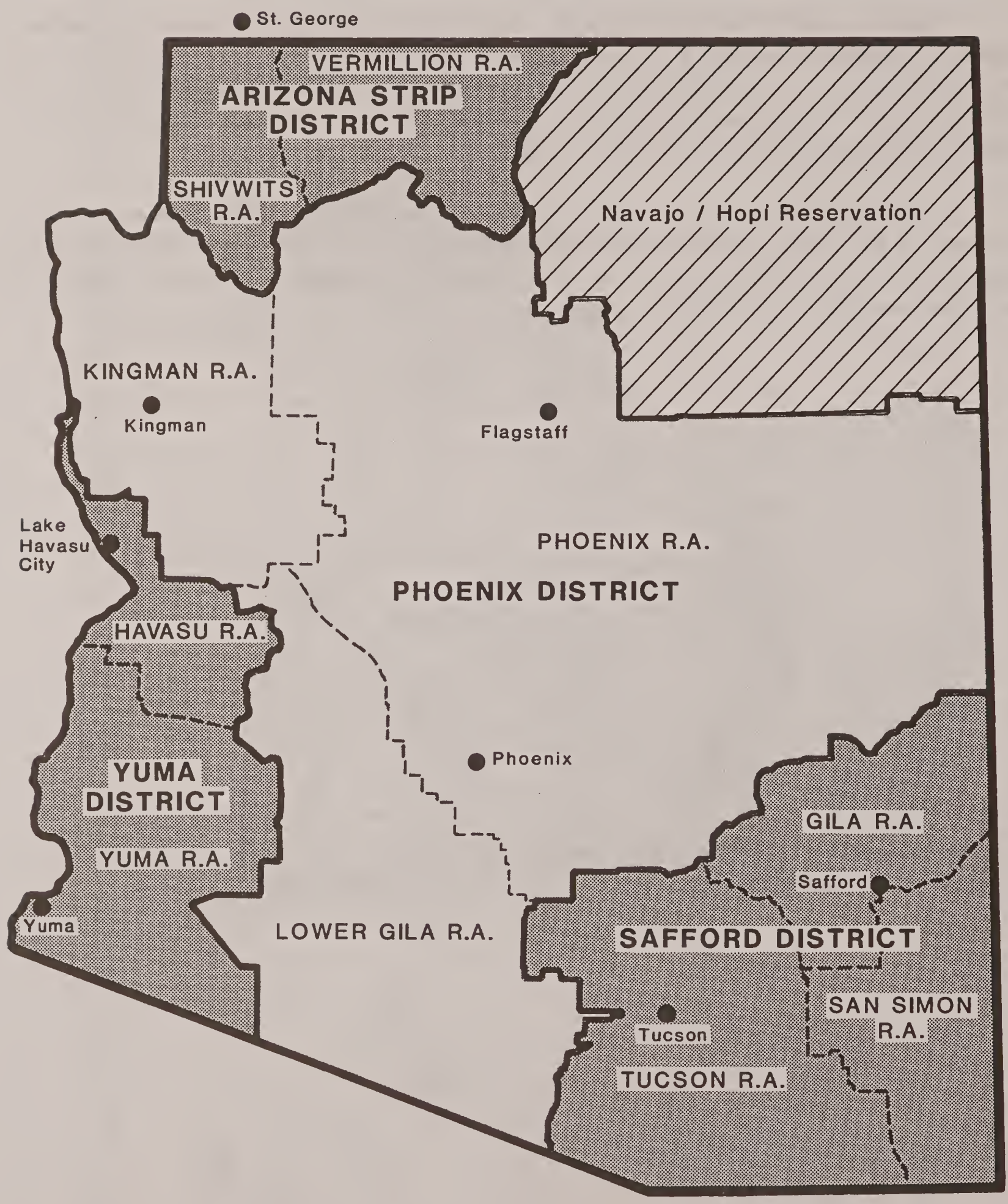
MAP 23

This was a colored map used in a BLM external affairs office type of document. As with a number of other maps reviewed, much of the text and many of the symbols are too small to be readable. This is particularly sad in this case because each state with BLM managed land is covered separately, and at much larger (readable) scale, later in the document. Thus, the inclusion of the excessively reduced material here was not necessary.

All this map really needed to display was the BLM land, state boundaries, state names, and (perhaps) the state office locations. All the other information is adequately shown on the following individual state maps. If this had been done, space for larger text sizes would have been available and a much more readable map would have resulted.

Lessons Learned: Just including a small-scale map in a document to show the "big picture" is not sufficient. The map must be adequately designed to be readable.

ARIZONA BLM DISTRICT AND RESOURCE AREA BOUNDARIES



MAP 24

This is actually a well-done map. It was designed to be used as a "graphic" to display the BLM district and resource area divisions in Arizona, and their relationship to each other. Note that there is no "extraneous material" included. Only the necessary elements are shown, thus keeping the map clear, concise, and easy to read. A few towns and cities provide location information for the districts and resource areas (these are generally also the sites of BLM offices). Perhaps a very simplified scale could have been added, but this was not required in the original graphic presentation of this map.

Lessons Learned: The simplest maps that portray the required information are the most successful.

SAN PEDRO HOUSE TRAIL SYSTEM

LEGEND

- Information
- Parking Lot
- *Wash*
- Trail
- Old Road Bed

NOTE: Trails and old road beds are closed to vehicle traffic.

Linear Pool
Old Road Bed
Railroad
Wash
RIVER
SAN PEDRO
Old Road Bed
To Tombstone or Bisbee
90
Bridge
Highway 90 Entrance
Entrance Road
Linear Pool
To Sierra Vista
SAN PEDRO HOUSE
Dry Ox Bow (Cottonwood Grove)
Large Cottonwood Tree
Green Kingfisher Pond
Old San Rafael del Valle Road Bed
Garden Wash
Black Phoebe Pond
SAN PEDRO RIVER
Railroad

ARIZONA
PHOENIX
TUCSON

MAP LOCATION

SCALE

0 ½ 1 Mile

0 ½ 1 Kilometer

MAP 25

Actually, there is nothing particularly wrong with this map, which is used as a handout hiking guide. It was included (as was Map 24) to see if the reader can discern a good quality map from among the other problem maps displayed in this document. The title is bold, brief, and descriptive. The legend is informative and includes all symbols which are not otherwise labeled on the map. The scale shows both miles and kilometers (a very good idea). The location map displays the map's location, not just within the state but also with regard to the two major cities of Arizona, Phoenix and Tucson. A north arrow indicates the orientation. A logo – of appropriate size – is even included. Although the trail system is somewhat complex in places, it is quite clearly shown and all important cultural and topographic features are labeled. Also, all text is of a reasonable size. In short, even though this is only a "sketch map" it is clear, readable, and understandable. Thus, it is cartographically successful.

Lessons Learned: The reader should be able to quickly and easily understand what all symbols included on a map represent.

U.S. Department of the Interior
Bureau of Land Management

Phoenix District Office

Burro Creek Recreation Site

ARIZONA

MAP 26

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Further Information:

For information concerning site availability, weather conditions, recreation site regulations, or available activities, write to:

Bureau of Land Management
Phoenix District Office
Kingman Resource Area
2475 Beverly Avenue
Kingman, Arizona 86401
or phone: (602) 757-3161

BLM-AZ-AE-92-007-8300

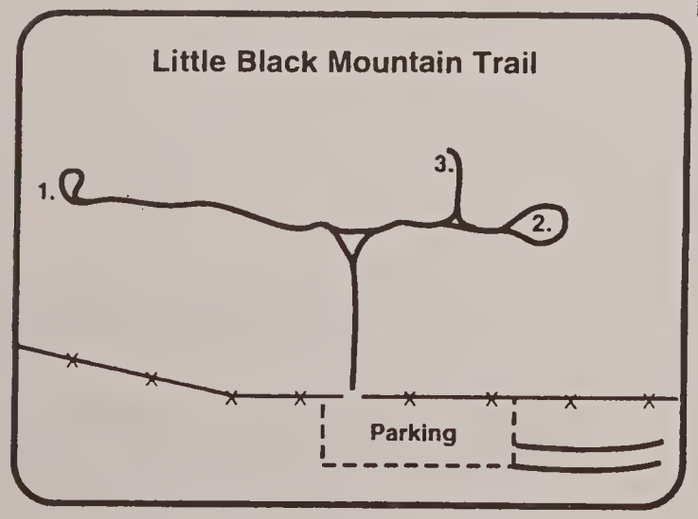
MAP 26

This is a 3-fold brochure designed as a handout. One side is shown; the other side contains text about the recreation site. The problem here is that there are *no maps* in this brochure at all – to indicate the location of the recreation site or how to reach it! As is obvious in this illustration, there is plenty of space available to include the maps (two entire panels). Any agency that deals with the land and spatial relationships upon it *must* include maps in the descriptive literature.

Lessons Learned: Brochures and other documents that discuss geographic sites must contain descriptive maps of those sites.

What do they mean?
Scientific study and comparisons to modern Native American art allows us to guess what some of the petroglyphs may signify. Based on age and stylistic differences, we know that different cultures made them.

Petroglyphs represent the artistic nature of a people long gone and meanings long forgotten. One fascination of petroglyphs is that they mean different things to each individual. You are welcome to make your own interpretation of these ancient rock art figures. A general description of three of the most prominent rock art panels follows.



Trail Guide

Stop #1.
This is the largest petroglyph panel at Little Black Mountain. Close examination shows that people from at least three different periods produced these petroglyphs. Individuals from the Archaic and early Anasazi (Basketmaker) cultures, 5,000 to 1,400 years ago, made the petroglyphs that are barely visible today. Late Anasazi people (700-1200AD) probably made the more distinct glyphs.

You may notice some of the more recent glyphs overlie older designs. The placement of one glyph over another may be an attempt to remove or assume the power of the underlying glyph. The large upside-down bird figure may represent a hummingbird. The long line may be a depiction of a life-line from someone's vision quest. The vertical line with the circle may portray access to the spirit world.

Regardless of the culture that made them, most of the glyphs seem to relate to life, death or communication with gods or spirits. Some of the glyphs may represent specific seasonal, agricultural or coming-of-age events. Others may be astronomical symbols and represent calendar or other specific activities.

The large rock to the left also has many older glyphs on it. Many of these are hard to see unless the sun is in the right location. Look closely at the lichens and you will see some growing inside sheep and spiral petroglyphs.

Stop #2.
The petroglyphs on this rock may have a timekeeping function. The majority of the glyphs seem to relate to the seasons, astronomy or time as shown by the spirals and two calendar glyphs. One human figure and possibly a second have horns, which is a common depiction of a shaman or medicine man. The animals and insects may be symbolic messengers. Here you see at least four different styles from Archaic through Anasazi periods. This panel represents a time span of about 6,000 years. The word ZENO is an example of historic defacement.

Stop #3.
This rock panel contains many sheep figures of the same style. Footprint depictions may be shaman signatures. These glyphs may be symbols for good luck on a hunt or other messages. The upside-down human figure may be telling of a death, possibly a hunting accident.

Hunting and gathering people of the Archaic and Basketmaker cultures made the older glyphs.

Petroglyphs on other rocks probably represent isolated events. Please respect this place of the "ancient ones" by taking nothing but pictures and leaving nothing but footprints.

For more Information

Bureau of Land Management
Shivwits Resource Area
225 N. Bluff Street
St. George, UT 84770
Phone: (801) 628-4491

Arizona Strip District Office
390 North 3050 East
St. George, UT 84770
Phone: (801) 673-3545

See also the BLM Arizona Strip Visitor's Map.

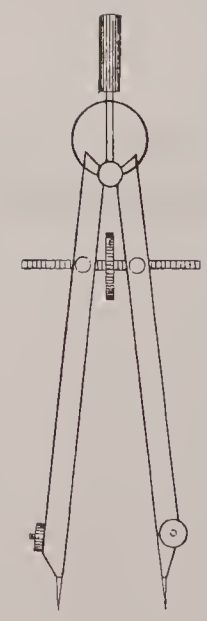
The BLM expresses its thanks to the Dixie Chapter of the Utah Statewide Archaeological Society, Technical Services, the BLM fire crew and individuals who have contributed many hours of volunteer effort to the development of this site.

BLM/AZ/GI-94/002+8300

MAP 27

This is another brochure, with 4-folds, designed for handout. Three panels are shown, all the rest are text. Note that there is a site map for the "Little Black Mountain Trail," which is well-done. Unfortunately, nowhere in this brochure – on either side – is there a general location map. Is the "Little Black Mountain Petroglyph Site" located somewhere in Arizona, or Utah, or Canada? How are we to know?! (The text doesn't give the location either, although we *might* glean some information from the "For more Information" addresses.) Since brochures are usually distributed widely (and not necessarily just close to the geographical site of the brochure's subject) an overall location map should be included. (In this case, a map as simple as an Arizona outline with a prominent dot indicating Little Black Mountain would have sufficed.)

Lessons Learned: Brochures concerning a specific geographical site should always include a map which shows the regional location of that site.



CARTOGRAPHIC ESSAYS

Essay 1: *THINKING* ABOUT THE MAP

Before constructing a map one should allow some time to sit down, relax, and just *think* about the map. Many inexperienced cartographers, when faced with a project, immediately begin to design and draft the map – quickly pulling together various elements with little consideration to the overall purpose required. Their maps usually result in a mass of detail in which the overlying theme tends to become obscured, thus producing a less than adequate product. A more relaxed approach, in which the various factors involved are given some thought, will result in a better map. A few things to consider would include:

Content: What is the purpose of the map; what is it being designed to show? This information generally should be the largest and boldest data presented on the map. It should "stand above" the other base material, which indicates the geographic location of this primary information. Care should be taken to avoid including unnecessary or extraneous material on the map, which only adds to its complexity. This makes it more difficult to read and consequently, the main message may be lost. Today, computer cartography has made this a special problem. When map layers may be added at the stroke of a key, there is a temptation to show "everything." This quickly results in a product that is so "busy" it is essentially unreadable.

Audience: The people for whom the map – or graphic – is being created should always be taken into account. What is their education level? Are they familiar with the subject matter? What is their level of map reading skill? Obviously a map designed for a technical scientific purpose should be different from one created for the general public. While we don't want to "talk down" to our audience, *understanding* is the key. If the reader is unable to understand the map, it is going to be a failure.

Inclusiveness: The map should be able to "stand alone." By this I mean that the information it contains must be complete, without the necessity of referring to other sources. The reader should be able to understand the map's message entirely from the map alone. All necessary legend and other information should be present. In certain cases, for instance where a series of very similar maps are contained in a document (and space is a problem), a "group legend" may be located on one page at the start of the map section. Obviously, the legend must apply to all the maps included. However it is better, if possible, to have each one tell the *whole story* individually. This is especially important for maps used as displays, or in presentations (as vugraphs or slides). In these cases they must really be able to "stand alone."

Essay 2: DESIGNING THE MAP

One way to design a map and avoid the problem of its becoming too cluttered, and therefore unreadable, is to use the "priority build-up technique." (This is a particularly good method for novice map makers.) Let's use an example of a trail map to show how this works. First, on your blank piece of paper or computer screen, draft the trail. This is the most important element of the map. Indeed, it is the reason *for* the map. Next, decide *in priority order* what other elements the map needs. Normally these would be locational items to give the site its context. Gradually build-up the information on your map. In our trail example you might want to add roads (to show how to get to the trailhead), streams & lakes, vegetation, physical relief, or even land status. The point is to include only those features – and a suitable number of them – that add to the understanding of the map without making it overly cluttered. In all cases the main purpose of the map (the trail, in this example) must stand out boldly and be the central prominent feature. If space is tight around the map edge, sometimes supplementary material can be omitted. For example, a legend and scale will undoubtedly be required but perhaps you can do without a north arrow and logo. Again, only the necessary elements should be included to keep the map simple and "to the point."

Occasionally a map must have too much information displayed to make it easily readable. In that case there are several techniques that may be employed to solve this problem. One method would be to produce two or even three maps of the same area, with the same primary feature (the trail in our example), but with different base material (streams and relief on one map, roads and land status on another). Another method is to enlarge the map and have several individual maps cover the same area – with more space for detail consequently available. A third method is simplification of material. In each case the goal is the same: to make the map readable, understandable, and to get the message across to the reader.

Essay 3: CARTOGRAPHIC CONVENTIONS

There are certain standard procedures that are used on almost all maps; these are called "cartographic conventions." One example would be placing the map with north at the top. If the map is oriented in any other way, a north arrow *must* be included to show its direction. A second example is the use of *italic* text to delineate only hydrologic features. The concept here is that *italic* gives the impression of *flowing* water. This helps to distinguish these types of features from all others. A third example is the use of the color blue to indicate water features, while using brown or green to designate land features. The reason for this is because, psychologically, most people associate water with the color blue. (Of course, water is actually colorless. We think of it as blue because it often reflects the blue of the sky.)

Why should we use these (and other) cartographic conventions? The answer is that the map is, in final analysis, a *communication* tool. Anything that can be done to speed or simplify the communication process (and thus the *understanding* process) should be utilized. Using the examples above: (1) The vast majority of maps have north at the top, so design them that way unless there is an overriding reason to do otherwise. (2) If bodies of water are in *italic* text, they are very easy for the reader to distinguish from all other features. (3) Most people expect the oceans and lakes to be blue on the map, so why confuse them with other colors? If at first glance they have already characterized the land and water areas in their mind, they are already well on their way to an understanding of the map content. Since understanding is the ultimate goal of the map, cartographic conventions help greatly in achieving this purpose. This is why they should be used on the vast majority of maps.

Essay 4: MAP RELIEF

Since the surface of the Earth has a third dimension – mountains, valleys, and the like – it is often very useful to include this vertical relief in a map. Of course, the decision to show this depends upon the purpose of the map. It may not be appropriate for some maps and almost mandatory for others. When relief is to be added, there are several ways to accomplish it.

A method of showing the lay of the land often encountered on older maps is the use of hachures, or closely spaced short line strokes. This can be quite effective in the hands of an expert, but it is rarely used today.

Topographic maps usually use contour lines to show exact levels of elevation. These are the most accurate relief maps but it is sometimes difficult for a novice map reader to understand the landscape from the contours (it takes some practice). Many newer maps add a slight shading component which is a great improvement in visualizing the terrain.

Shaded relief maps delineate the land surface by the use of shading – to give the impression of shadows across the landscape. This method is very effective in enabling the reader to visualize the terrain; on good quality maps it gives the illusion of seeing the ground from high above it in an aircraft. Shaded relief maps generally do not provide elevations. However, spot elevations can be added to include this information (such as on mountain peaks, in valley bottoms, at city centers, etc.).

In general, the method of relief representation used depends upon the purpose of the map. Sometimes the "best of both worlds" will work, with a combination of shaded relief and a moderate number of contour lines or spot elevations. However, great care must be taken to make sure that the map does not become too cluttered with information, and consequently fails because it is too difficult to read. *Careful design* using shaded relief can result in a very effective map.

Essay 5: MAP ACCURACY

How accurate must a map be? The obvious answer is "as accurate as possible." But, can we really talk about accuracy when, as the saying goes "all maps are out-of-date when they hit the press." The question then becomes one of "degree." You can spend so much time (and therefore money) on exacting work – say the location and alignment of very fine grid lines that are barely visible to the naked eye – that the cost of the map becomes prohibitive. On the other hand, if major errors are made – for instance the land status of large parcels of land – the map displays incorrect information and becomes worthless (and in the process casts doubt on other maps by the same agency, even though they may be correct). So, what is to be done?

It is up to the cartographer to allow as much time and effort as is feasible, to make sure the map is accurate. (Saying that the map will go out-of-date is not an excuse!) This includes using his expertise to draft the information on to the map in as exacting a manner as he can – whether traditional or computer methods are being used. It also includes making sure the base data is correct. This is especially important today in computer cartography, where a base layer may be added to the map at the tap of a button. The cartographer must check his data to make sure that it is correct. At the very least, he should use data that he has "spot checked" from a very reliable source in which he has complete confidence.

In the last analysis, the final accuracy of a map is a "judgment call" by the cartographer. If he is a true professional he will have used all the elements and time at his disposal to ensure that the map is as accurate a product as can be produced.

Essay 6: CARTOGRAPHER "IN THE LOOP"

Whenever any project planning is undertaken by management, a cartographer should be included on the committee / team if the production of a map (or maps) is going to be a resultant product. It is important to have the cartographer involved ("in the loop") because his special expertise is needed in the planning process, both for questions of a spatial nature and also for the final design of the project maps. In addition, the cartographer needs to know – ahead of time – about the quantities of new maps that may be desired and the time elements that will be required for their production. If a map *series* is to be produced, design consistency across the series will also have to be planned.

In the past, cartographers have often not been included in the planning process by management. The result has usually been to "surprise" the cartographic staff with one or more of the following deleterious results: (1) The maps are hurried and consequently the final quality is lower. (2) There may be no time for editing, therefore the accuracy will be compromised. (3) They may be more expensive because of "rush charges." (4) Map series may not be consistent because of lack of time for coordination between field offices. (5) If the time element is too short (or there is not enough staff available) the map may be impossible to complete, resulting in the loss of grant money. All of these problems can be alleviated by including the cartographer in on the "ground floor" of any future project planning and taking into consideration his professional advise.

Essay 7: EDITING AND MANAGEMENT

All maps that are going to be distributed or viewed by the public should be reviewed and edited. This includes published maps, those that are to be used as slides, vugraphs, or computer visuals in presentations, and those that are to be displayed as exhibits. The reviewer must be a competent professional trained in cartography and graphics. The maps should be edited for content, accuracy, and clarity. In particular, do they correctly portray what they are designed to show, in an easily understandable fashion?!

It is up to management to make sure that the map editing is always done and that it is completed correctly. Fast deadlines and "hot" projects are no excuse for lack of editing. At least a cursory review should be accomplished in an "emergency." The quality of the maps directly reflects upon the credibility of the agency (and the personnel) that produced it. In the "big picture," it impacts the public's opinion of the civil service and federal government.

Essay 8: THE FUTURE OF CARTOGRAPHY

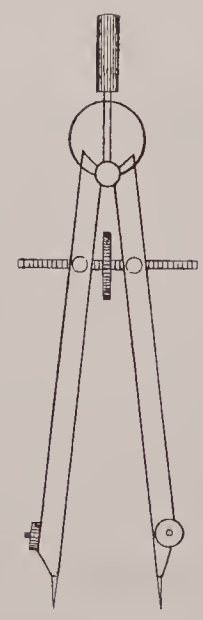
Cartography is an old science whose roots go back into ancient history. Over the past few centuries all quality map making has been accomplished by highly trained and experienced cartographers – professionals in their field. This situation has changed radically over the past decade, however.

Today, with the advent of easily accessible mapping programs, computer cartography has made it possible for almost anyone to create their own maps with the stroke of a few keys. The problem with this capability is that many of the people designing the maps don't have the basic cartographic background or knowledge to produce quality products. Many of the maps displayed in this document readily attest to that. An analogy of this situation might be as follows:

A group of tribesmen from central New Guinea arrive in town and it is your job to teach them to drive automobiles. Could you do it? Yes, you probably could. These folks are of average intelligence and (once you get past the language barrier) you could, with a little work, get them trained. You stake out a large empty parking lot and get started. With a few weeks of practice you would have them driving the cars in different directions at different speeds, perhaps even checking the oil level and tire pressures on the vehicles. Now that they are fully proficient in operating the automobiles, you let them out onto the city streets. Will they be successful drivers? Of course not! You have trained them to operate the vehicles, but you haven't instructed them in the *rules of the road*. Your new students will be out there driving down streets in the wrong direction, going through red lights, crashing into other cars, and – in general – creating havoc! They don't have the traffic instruction rules that they need to drive correctly. Likewise in cartography, we have given the average person the ability to create maps on the computer (we've trained them to "drive the cars") but they don't know the basic rules of cartography (the "rules of the road").

What is to be done? It is unrealistic to believe that these amateur map makers will have the time – or inclination – to gain the basic knowledge that is required. Consequently, for the near term, it will be necessary to review and edit any maps that they produce before these are distributed to the general public (see Essay 7). In the more distant future – perhaps in a decade or so – this will change. By that time computer programs will become so sophisticated that they will not allow the user to make a major cartographic mistake. In all probability, the keyboard will be gone and you will speak into a microphone directly to the computer. You will tell it what you want on the map and it will do all the work for you – in a cartographically correct fashion. When we reach this point, cartographic errors will be essentially a thing of the past. But, what will we really have done? Actually we will have, in a sense, returned to the past. In the "old days" a *professional cartographer* rendered the accurate map for the customer. Now the accurate map will be rendered by *the computer* for the customer. The final result

will again be the same – a quality map. The only difference is that the computer (a robot?) will have replaced the cartographer!



APPENDICES

Appendix I: GRAPHICS

Although this document is primarily about maps, graphics are often used in association with the maps in presentations. Consequently some suggestions and samples of graphics for use in presentations are included in this section. This material is also appropriate for displays and exhibits.

BILL WILLIAMS RIVER-WATER BALANCE

$$Q_{release} = Q_{isf} + \left[Q_t + (GW_{out} - GW_{in})\right]$$

where:

$Q_{release}$ is release discharge (cfs)

Q_{isf} is fish requirement (cfs)

Q_t is transpiration loss (cfs)

GW_{in} is groundwater gain (cfs)

GW_{out} is groundwater loss (cfs)

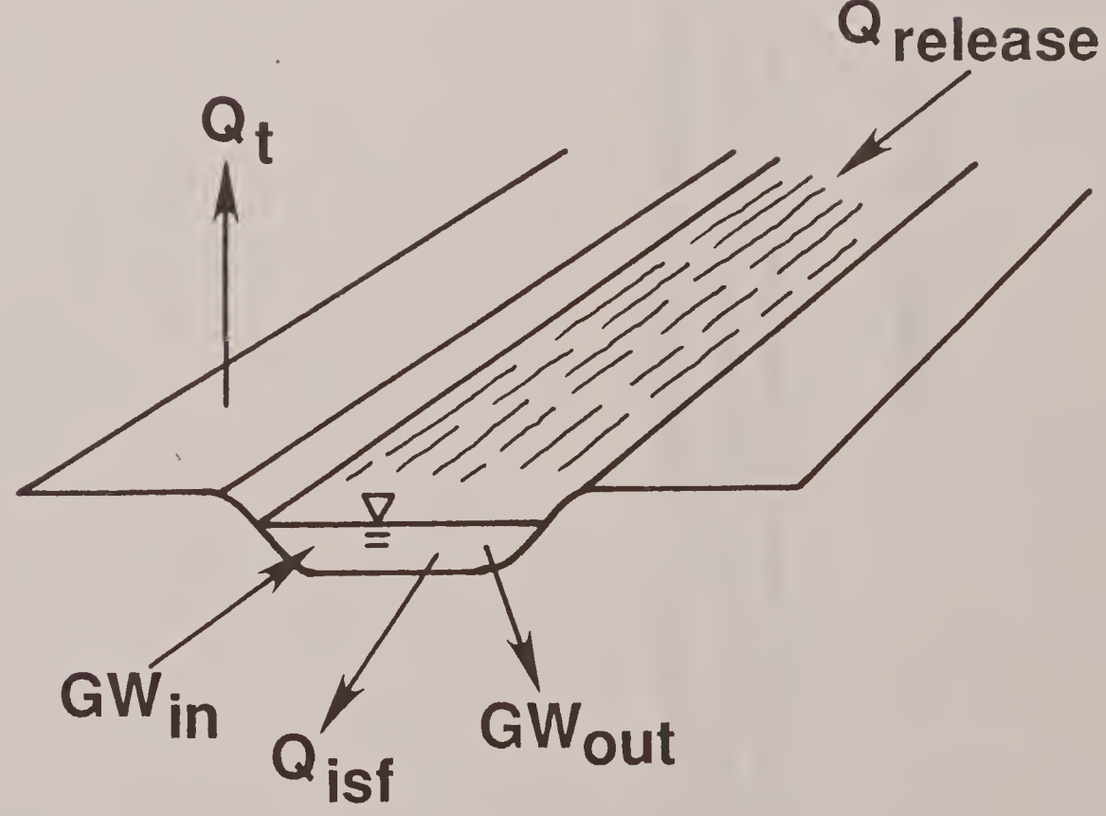


FIGURE 1

Figure 1

This is an example of a well-done graphic designed for use as a slide or vugraph (overhead transparency). Note that even though it is of a technical nature, it is clear, concise, and easy to read. The line weights and text are bold and large enough to be readily seen when projected onto the screen. Only those subject elements which are absolutely necessary, are included in the graphic. This enables it to be clear (ie, not "busy" and thus confusing) and consequently easy to see and understand.

FLOW DURATION ANALYSIS OF NORMAL MONTHLY MEAN FLOWS

Bill Williams River, WY 1970-1986

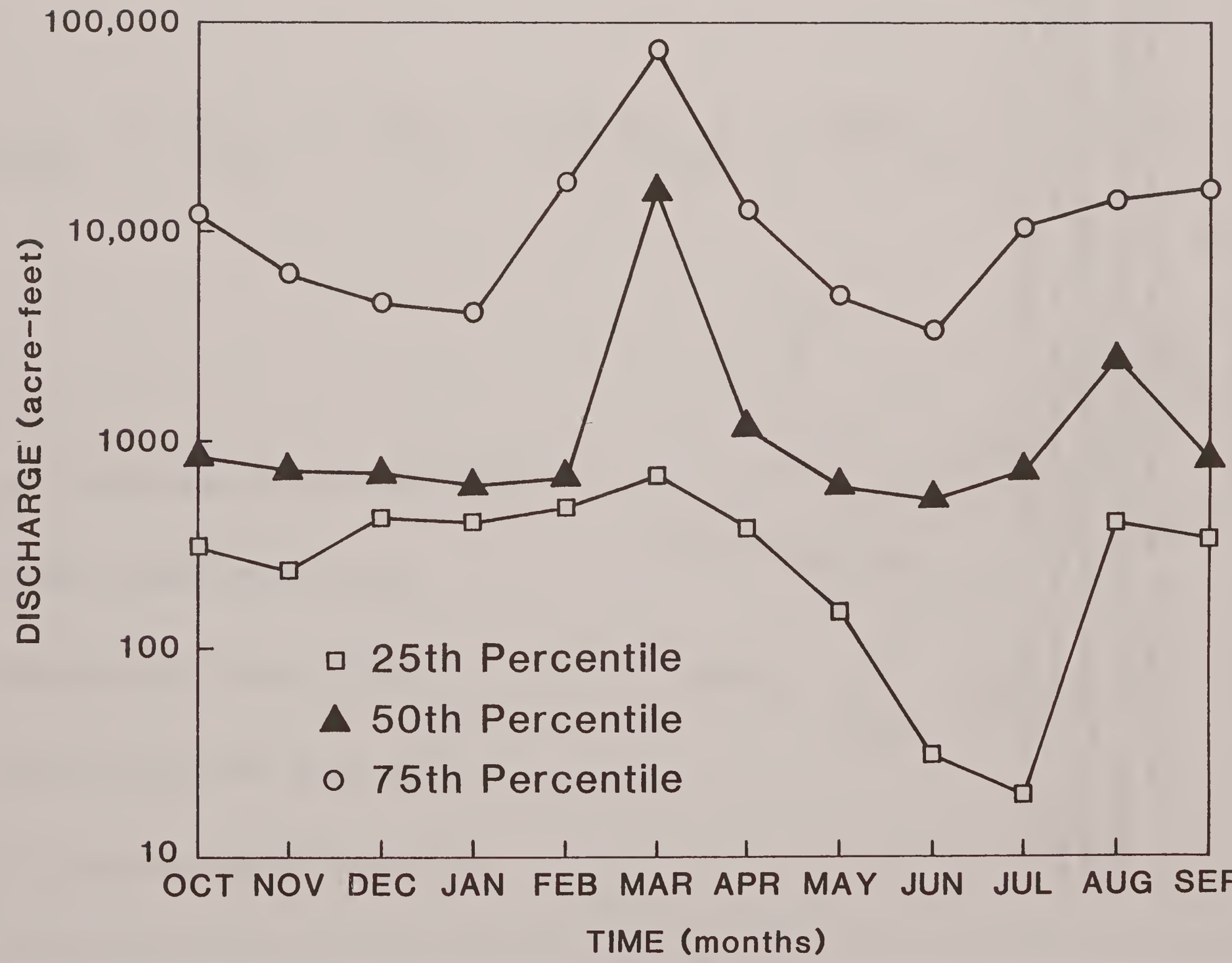
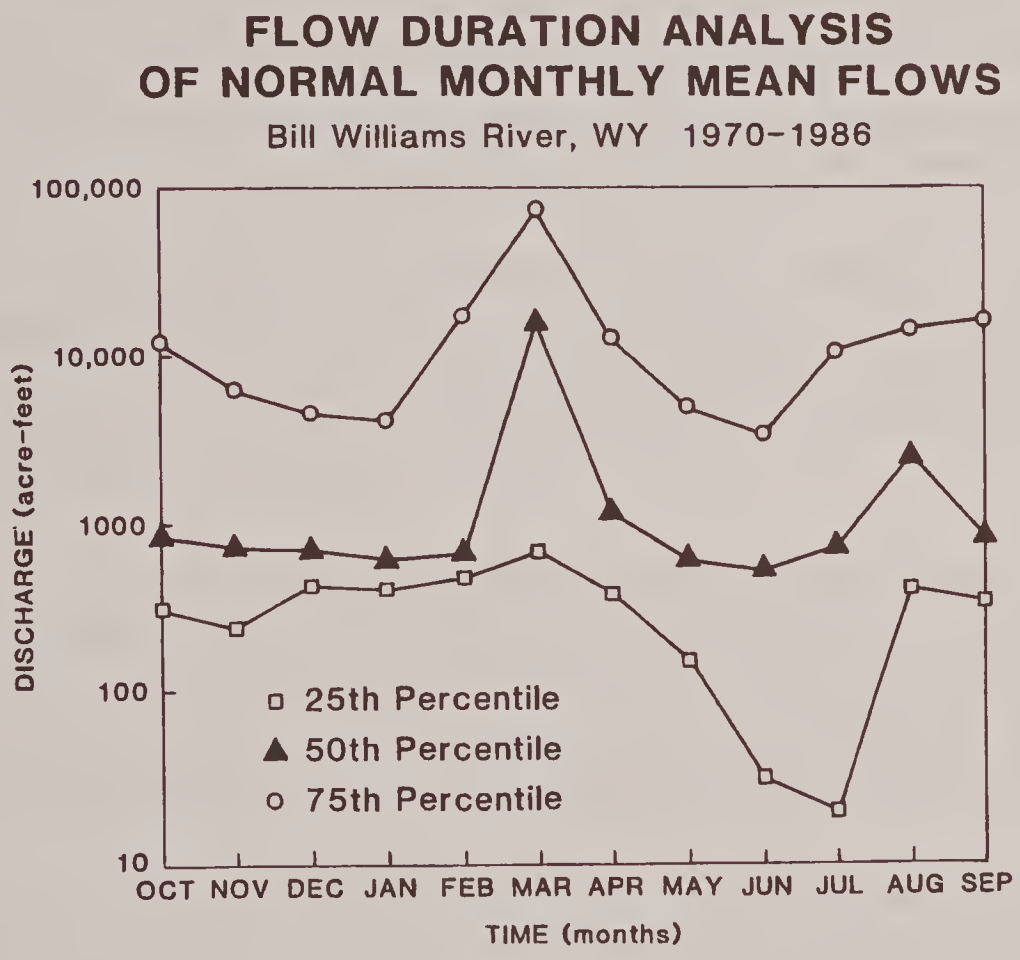


FIGURE 2

Figure 2

This is an example of a technical graph designed for use as a slide or vugraph (overhead transparency). Note how clear and clean the illustration is, making it easy to read and comprehend in the brief time available while it is projected onto the screen.

Incidentally, because this diagram is well-designed it could easily be reduced to 50% of its original size for a journal article (see below). It could also be used in a display for a "poster session," although I would recommend enlarging it to 200% for better visibility from several feet away.



Graph at 50% reduction.

Appendix II: PRESENTATION TECHNIQUES*

Maps, graphics, photographs, and text are often used in presentations. Unfortunately, many times the results of these presentations are less than sterling. Here are a few suggestions for making your lectures, before groups of people, successful.

(1) The subject matter of your talk should be appropriate to the education and experience level of your audience.

(2) Visuals – maps, diagrams, graphs, etc. – should be clear (large enough to be seen), concise (not overly complex for the brief time they will be visible on the projection screen), and understandable to the audience. For best results the visuals should be designed *specifically* for the presentation, rather than copying them from other sources. Maps in particular have a tendency to fail in this regard. They are often photo-reduced for the presentation and, as a result, become unreadable on the screen.

(3) Text should be kept to an absolute minimum on the visuals. Generally only "subject headings" should be displayed to keep the lecture organized for the audience. If too much text is displayed, you will force your audience into a choice between reading the text *or* listening to you. More than likely, they'll try to do both at the same time. This will result in confusion and perhaps a lack of understanding of the salient points of the presentation.

(4) The major text – the detailed information (and complex maps & diagrams) – should be supplied to the audience as a *handout*. It is recommended that an announcement be made explaining that this material will be distributed *after* the lecture. This way the audience will be listening to you and not have their attention compromised by reading the handout while you are speaking. (I would have a stack of the handouts placed by the rear exit, so any people that had to leave early could get a copy.)

(5) Primarily visuals (pictures, photographs, and *simple* maps, diagrams, and graphs) should be displayed during the presentation. This will keep the audience focused upon you – the lecturer – and your presentation to them. They can get the detailed information from the handouts – which they may study at their leisure after the lecture.

(6) Avoid excessive "circus-like showmanship" in your presentation visuals. Complexity, overabundant colors, unnecessary movement (easily done in some computer presentation programs), and allowing too limited a time to view each visual will lead to confusion by the audience. They will leave your lecture remembering the "medium" but not the "message." This is not the purpose of your presentation.

(7) Finally (again), make sure all your visuals are large enough on the screen to be easily seen – even by the people in the back row. And, speak loud enough so that you can be heard by everyone in the room. If you can't speak loud enough, or if it is a large room, use an audio amplification system.

* Much of this information is also appropriate for use in displays and exhibits.

TYPE SIZES

4 POINT TYPE Point Type

5 POINT TYPE Point Type

6 POINT TYPE Point Type – *smallest acceptable mapping size type*

7 POINT TYPE Point Type

8 POINT TYPE Point Type - *ideal smallest mapping size type*

9 POINT TYPE Point Type

10 POINT TYPE Point Type

11 POINT TYPE Point Type

12 POINT TYPE Point Type

14 POINT TYPE Point Type – *smallest acceptable slide / vugraph size type*

16 POINT TYPE Point Type

18 POINT TYPE Point Type – *ideal smallest slide / vugraph size type*

20 POINT TYPE Point Type

24 POINT TYPE Point Type – *smallest acceptable display / exhibit size type*

30 POINT TYPE Point Type

36 POINT TYPE Point Type

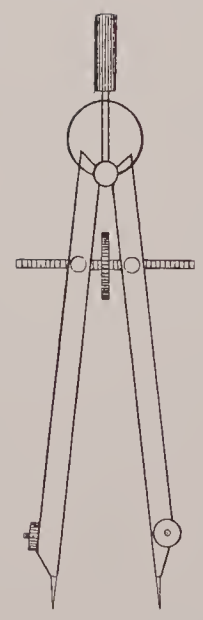
Appendix IV: FINAL THOUGHTS

As this document goes to press a few "final thoughts" come to mind:

(1) When sending a map or graphic to a photographer or printer for reproduction, it is always wise to include a *sample* which indicates the "exact colors" that you require. That way the photographer / printer has something to match; also there is no question whether the final job was done correctly (if the colors don't match, the job should be rejected).

(2) When a single large map is divided between two or more sheets (including front and back sides of a single sheet), allow an *overlap* of at least an inch between the adjoining pages.. That way the same edge features will appear on both pages and it will be much easier for the reader to orient himself between the two maps.

(3) And finally: The author has been actively doing cartography for over 45 years. In all that time I have never made or supervised a map that – if I had it to do over again – I would not modify slightly to make it better. If I feel that way after the thousands of maps that I have produced, the novice cartographer should not be overly concerned about his first mapping attempts. Just do the best that you can, consult some of the professional cartography textbooks (see the Bibliography) for guidance, and remember the "Golden Rule of Cartography" – *a map must be readable, understandable, and accurate."* Map making is an enjoyable pastime and profession. I hope you enjoy it!



BIBLIOGRAPHY

There are a number of excellent cartographic textbooks available that cover the entire range of map making and production. A few are listed here. It is recommended that the most recent editions be obtained if the reader is going to work with computer cartography. Older editions (naturally) concentrate on manual procedures. All the editions contain valuable guidance on the *basics* of map making, necessary to all maps whether constructed by computer or traditional methods.

Elements of Cartography by Arthur H. Robinson, et al.

Cartography: Thematic Map Design by Borden D. Dent

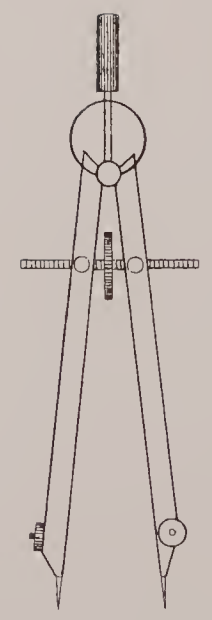
Cartographic Design and Production by J. S. Keates

Introductory Cartography by John Campbell

Cartography: Visualization of Spatial Data by M. J. Kraak and F. J. Ormeling

Maps and Diagrams by F.J. Monkhouse and H.R. Wilkinson

Mapping by David Greenhood



ABOUT THE AUTHOR

Stephen Meszaros has been involved in the cartographic and graphic field for over 45 years. (He began actively drawing maps in grade school, on everything from note paper, to flattened paper bags, to old window shades!) Steve graduated from Delaware Literary Institute & Franklin Central School, in upstate New York, with School and Regents Diplomas in Science & Mathematics. He also received the school Geography Prize. At Syracuse University he took his Bachelor's Degree in Geography, specializing in cartography and physical geography. This was followed by 4 years in the U.S. Air Force as a Drafting and Cartographic Supervisor for the Aerospace Cartographic and Geodetic Service, based in Kansas. During this time he spent a year in Brazil and 6 months in Vietnam. Following military service Steve completed a Master's Degree in Geography at Arizona State University, concentrating on regional geography and historical & contemporary geographic thought.

Steve's civil service career began with the U.S. Geological Survey at the Center of Astrogeology in Arizona, the Water Resources Division in California, and the Special Mapping Center at USGS Headquarters in Virginia. In these positions he was a scientific illustrator, cartographer, and map editor. This was followed by 10 years with NASA as a visual information specialist for the Goddard Space Flight Center in Maryland and the Ames Research Center / Dryden Flight Research Facility in California. During this period of time Steve took a 6 month break in government service to become the Chief of the Public Affairs Office at Kitt Peak National Observatory in Arizona. For the past 13 years he has been a visual information specialist for the Arizona State Office of the Bureau of Land Management.

Steve's maps and visuals are used across the United States. His displays and exhibits have been shown in the U.S. and Europe, and his slide sets are featured world-wide. Most major astronomy textbooks contain his illustrations, as do many popular-level space science books and journals. His work has appeared on television and the World Wide Web (and one of his visuals has even been made into a jigsaw puzzle!)

Steve has been the recipient of many honors throughout his career, including the prestigious NASA Outstanding Service Award. He is the author of over 20 publications for NASA and the astronomical and educational community. Following retirement from the government with over 30 years of service, Steve plans to continue his work as a consultant to NASA and various universities.

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